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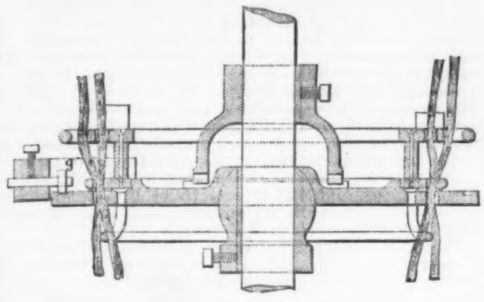


FIG. 1.

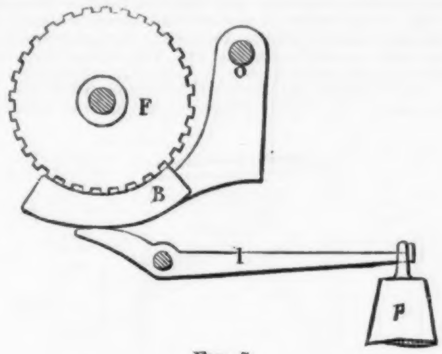


FIG. 5.

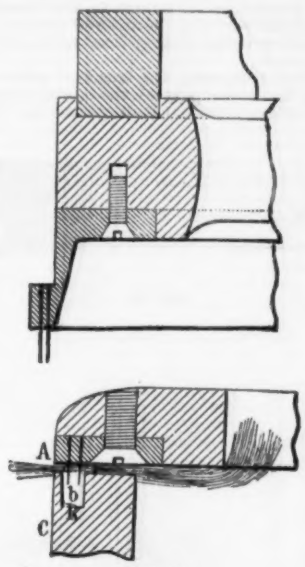


FIG. 7.

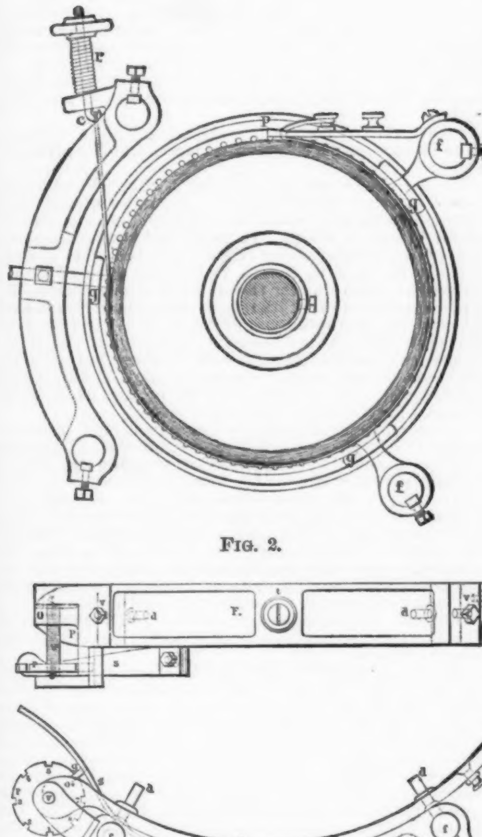
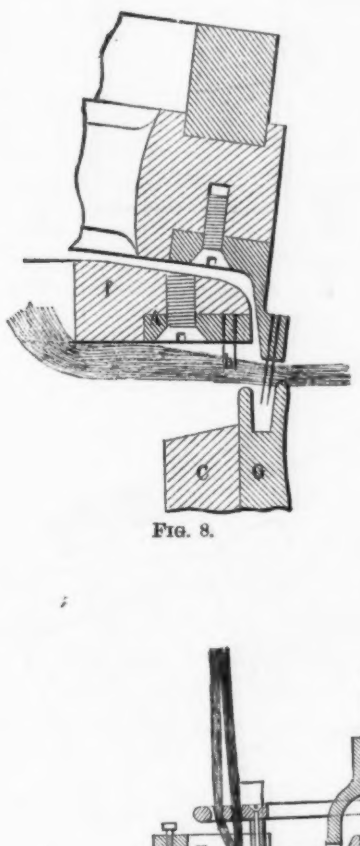


FIG. 2.



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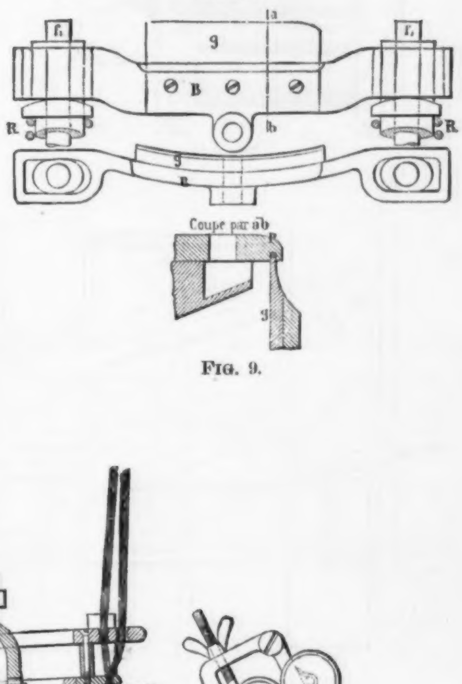


FIG. 9.

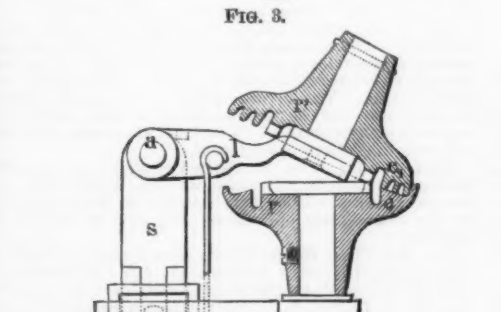
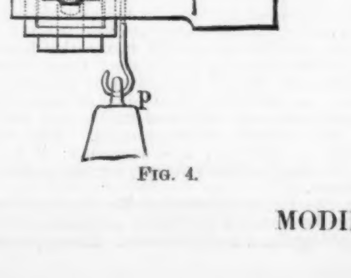


FIG. 3.



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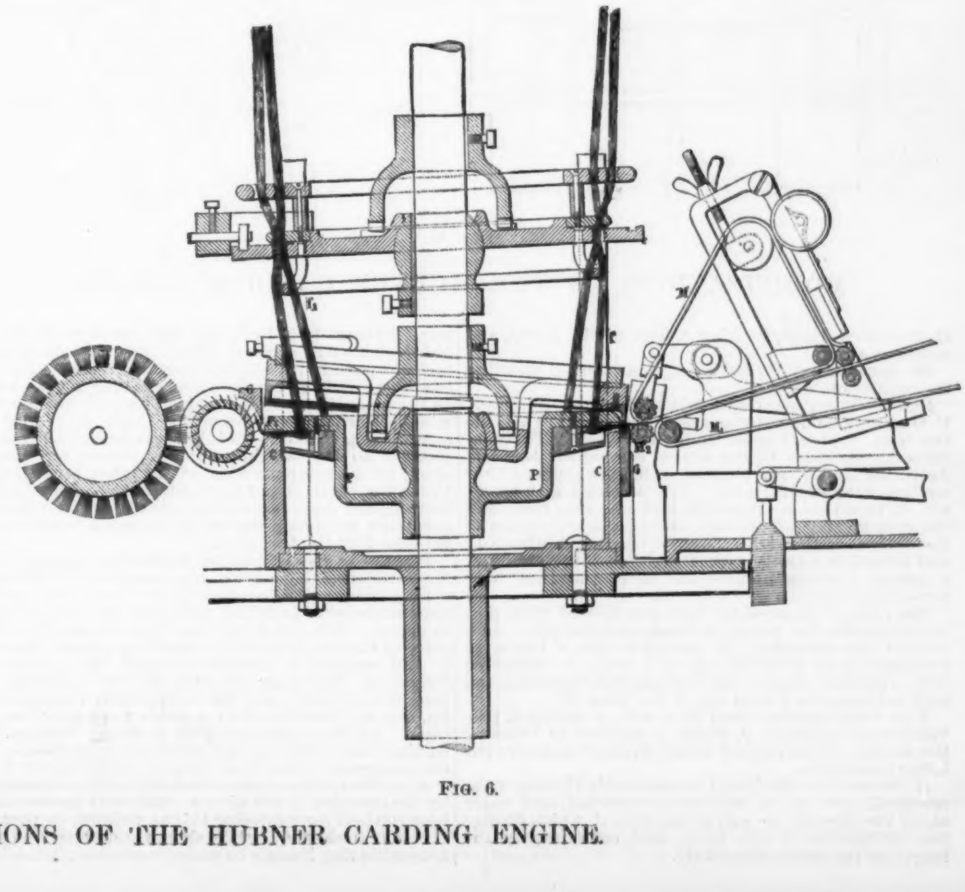


FIG. 6.

MODIFICATIONS OF THE HUBNER CARDING ENGINE.

THE HUBNER CARDING ENGINE, AND THE MODIFICATIONS THAT HAVE BEEN INTRODUCED INTO IT.

THE formation of the card end in the Hubner carding engine is, by reason of its simplicity, one of the most interesting features of the machine.

As the distance from the bobbins of the creel to the point where the real draught of the sliver is effected is great enough to prevent a too strong tension, that would interfere with the elongation of the ribbon, this motion, which must be as regular and uniform as possible, is aided by means of a feed plate placed between the two ends, and near the lower part of the apparatus.

Figs. 1 and 2.—This plate is regulated by three guides, *g*, which give it the proper slope to produce a descent of the sliver. These guides must have a certain play, in order to reduce friction and prevent breakages, but such play must be as slight as possible, so as not to produce variations in the descending feed length. Moreover, if it be desired to vary the size, it will be necessary to change the inclination, and to regulate anew.

In the first apparatus, the idea had occurred to cut a thread on the upper part of the guide supports, so as to render them movable through the aid of a graduated ratchet wheel, forming a part of the guide, and acting as a nut.

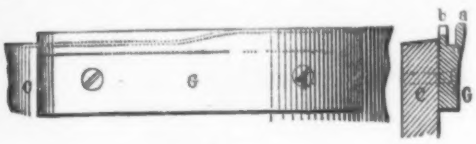


FIG. 10.

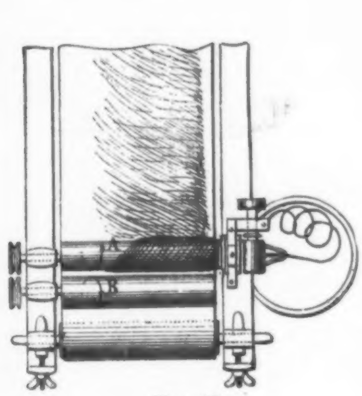


FIG. 13.

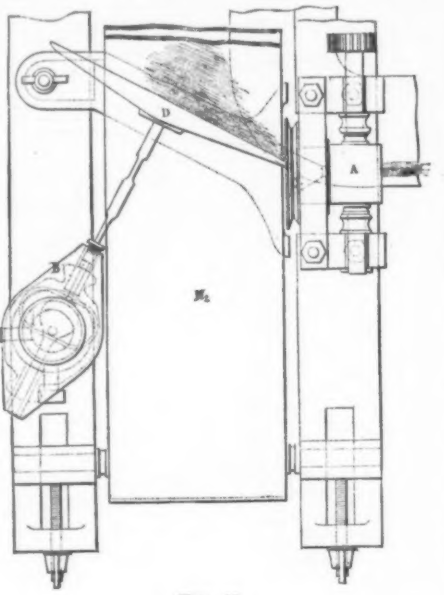


FIG. 12.

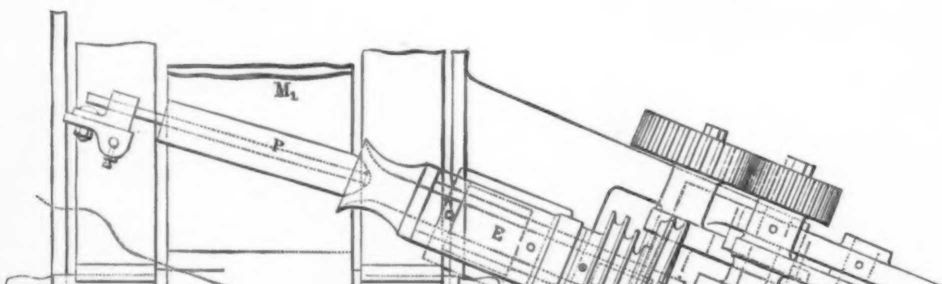


FIG. 11.

MODIFICATIONS OF THE HUBNER CARDING ENGINE.

Mr. Gspann has devised a simple method of effecting the regulation.

Fig. 3.—The apparatus consists of a cast iron piece, F, that may be fixed by means of screws, *v v*, upon the two bars, *f*, placed upon the delivery side. This contains an aperture in the center, into which is introduced the stud, *t*, of a piece of iron, P, which can thus oscillate around this point. It is provided with a button, C, to which is affixed the end of a wire that does the compressing. This wire, after passing into one of the notches of the end, *e*, partially surrounds the disk, and is fixed to a hook, *c*, that undergoes the action of a spring, *r*, which tautens the wire, and thus compresses the sliver.

The piece, P, is provided with two riveted pins, *d d*, which receive the pieces, *g*, that guide the plate, and, toward the extremity, is provided with a lug, *o*, so arranged as to form the nut of a screw, *v*, connected with a ratchet wheel, *r*, having numbered notches, and held between the forked end of the piece, F.

This latter carries, fixed by a bolt, a spring, *s*, provided with a detent, *g*, which is capable of entering the notches of the ratchet wheel, in order to secure the latter in position.

If the ratchet wheel, and consequently the screw, be revolved, the lug, *o*, will rise or descend, and carry along the piece, P, as well as the pins, *d*, which change the inclination of the plate, and consequently the length of the descending sliver.

If, after the apparatus has been put in place and regulated, we revolve the ratchet wheel in any direction we choose, it is easy to see that the play of the guides will remain the same. Moreover, if, through atmospheric or other causes, the size chances to slightly vary, it will suffice to revolve the ratchet wheel in order to obtain the size desired. Should such causes cease to exist, we must turn back to the first notch again. These notches are all numbered, and we know by experience that such a notch corresponds to such a size.

The descending sliver furnished by the inclined plate, P, must be drawn to the lower part by the roller charged with the feeding. This latter, which is covered with leather, has the following defect: the wire that encircles it, and bears against it through the action of a counterpoise, makes a groove in the leather, and finally cuts through it. In measure as the groove increases, the fibers follow this profile, the distance from the point where they are compressed to the turbine increases, and the feed tends to become irregular.

Fig. 4.—In order to remedy this inconvenience, Mr. Gspann employs two bevel wheels, *r r'*, that make with each other an angle of about 40°. The axis of the upper wheel is fixed upon a lever, *l*, jointed at *a* to a support, *s*. This lever is submitted to the action of a weight, *p*, that causes the upper wheel to bear against the lower one. Externally to its teeth, this lower wheel is provided with a rim, *c*, whose section is formed of a straight inclined part and a slightly rounded flange. The upper wheel likewise carries a rim, *c*, which is not so wide as the preceding, and is provided with three channels, whose bearing point upon the lower rim forms the compressing surface. This latter is brought as near as possible to the turbine, so that the cotton carried along by the rotary motion of the latter is caught between the parts, C and C, which carry it along in their motion, and draw it outside to an extent that must be regulated in such a way as to be equal to the length furnished by the feed plate.

Fig. 5.—As a substitute for the leather-covered roller, Messrs. Dolfus, Mieg & Co. have applied the following arrangement: Their roller, F, is of cast iron, and its circumference is provided with grooves about ½ mm. in depth. This roller revolves upon a smooth, curved piece of bronze, B, which is movable around the axis, *o*, and receives a pressure through the action of a weight, *p*. The wear between the two rubbing surfaces is very slight, and the compression remains regular, and can be effected at a point very near the turbine. As the apparatus has a rotary motion, the feeding takes place in succession for each ribbon, and the outspread cotton thus forms a small circular lap.

After the feeding comes the compression necessitated by the combing of the slivers. Different systems have been devised for rendering this as uniform as possible. It is easy to see that, as the slivers are spread out upon a metallic rim, if some be more prominent than others, the neighboring ones will run the risk of not being compressed by the upper plate, and consequently of going to waste under the action of the needles of the comb.

Fig. 6.—One system of compressing which has been, and still is, in extensive use, is that which effects it between the sides, P, of the turbine and the upper part of the box, C. To this effect, the turbine has an elastic rim, P', of leather or rubber cemented to its upper edge, and this rests upon the channeled part of the upper edge of the box, C. This channeled portion begins at a few centimeters from the feed roller and ends in front of the part where the fleece is removed. It is about 5 or 6 mm. higher than the other, and connected therewith by two small inclined planes. The pressure is obtained through the weight of the turbine increased by that of the vertical axle and of the parts that it supports—bobbin supports, feed plate, etc. The adhesion between the elastic surface and the cotton carries the latter along.

A subsequent arrangement has been made in which the turbine, instead of sliding over the channeled part of the cylindrical box, C, carries along in its motion a leather ring resting upon the channeled portion and running over guide pulleys. This ring must be cut in a single piece from one and the same piece of leather. The cotton is thus spread out between two elastic surfaces capable of undulating according to the form of the slivers. The ring alone supports the friction, which, in the preceding system, occurs upon the cotton.

The trouble with this ring is that it lasts but two or three months, and that it sometimes breaks suddenly when the machine is set running, and thus causes a breakage of the needles of the comb.

Fig. 7.—In order to overcome the inconveniences connected with changing the elastic rim and with the adhesion of the same, Mr. Baudouin has devised a compressor with metallic jaws, for which he has taken out a patent (Figs. 7 and 8). For the elastic rim of the bobbin, P, there is substituted a bronze ring, A, which is screwed upon the periphery and provided with two or more rows of short, stout needles, *b*, arranged quincuncially. The upper part, C, of the box is smooth and provided with a groove, R, in which the needles run while they are being carried along by the rotary motion. Here the adhesion of the elastic surface mentioned in the Hubner patent is replaced by points entering the fleece, and thus carrying the latter along.

Fig. 7 shows the arrangement on the side toward the carding roller, and Fig. 8 that on the side toward the doffer.

More recently, the Societe Alsacienne de Constructions Mecaniques has patented the following arrangement:

Fig. 9.—The lower part of the turbine, P, which is here of a larger diameter, is smooth, and contains in its circumference, at ½ mm. from its upper edge, a groove about ½ mm. in width. In front, and toward the bottom of the carding roller comb, there is a steel guard, *g*, about 200 mm. in length, the upper edge of which enters the groove under the action of strong springs, R. For a small portion of its length, this guard is inclined so as to facilitate the compression and movement of the card end. It is screwed to a cast iron piece, B, whose extremities engage with bushes that slide on the rods, *f'*, and secure a certain play. The springs bear against the boxes and the frame, and their compression may be regulated by a screw.

We must remark that, on comparing the different modes of compression, that by way of elastic surfaces appears to be the best, these latter being capable of undulating according to the form of the outspread cotton; and yet the results obtained with metallic surfaces seem to make the success of these secure. Does the advantage result from the slight adhesion between the metallic surfaces and the fibers? This does not seem very probable, and there is no telling but that tomorrow the originality of some investigator may give us back compression through elastic surfaces.

Moreover, the condensing, doffing, and formation of the sliver in this carder are three operations subject to many changes.

The combing of the card end is effected by a roller, in which the profile of the surface described by the points of the needles is a curve of a radius greater than that of the turbine. The card end is made to engage with these needles by a bronze guard, G, arranged at the upper part, and placed as near it as possible (Fig. 6). Some cotton manufacturers have found it advantageous to do away with this guard, by working with a carding roller whose surface profile described by the points of the needles is concentric with that of the turbine.

The doffing of the card end has undergone but slight modification. It is usually effected by means of a leather belt, M, running around a fluted roller, M², which is placed as near as possible to the turbine.

Fig. 10.—In order to cause the fibers to engage with the needles of the comb, the cylindrical box, C, on the doffing side carries a guard, *g*, consisting of a hollow piece of steel provided with a groove into which the needles enter. The arrangement of this piece, which likewise prevents the needles from getting broken, is not without importance. The form at present adopted is shown in section in Fig. 10, G.

Upon coming from the delivery rollers the combed filaments form a thin, continuous lap, which must be converted into a ribbon firm enough to be submitted to the succeeding operations, the first of which is drawing.

Fig. 11.—These filaments are placed upon a leather bed, M_1, which has a forward motion that rotates a cylinder, P, bearing against it. In front of this cylinder there is a funnel, E, which receives a rotary motion, which also actuates two compressing rollers, A, placed at the opposite extremity of the funnel. If a sliver of cotton be passed into the funnel and be compressed by the cylinder, A, and wound around the cylinder, P, the draught of the sliver will cause the fibers winding around the cylinder, P, to detach themselves and form a continuous ribbon containing a certain number of twists. An effort has been made to lessen the amount of such tension by means of the funnel and revolving can, but without entire success. The ribbon thus formed is not very homogeneous; it is unequally twisted, thus partially destroying the parallelism given the fibers.

Fig. 12.—It has occurred to Mr. Baudouin to form the ribbon by placing the fibers alongside of each other and giving them a slight twist. His apparatus consists

of a wooden device, D, that rests upon the bed, M₁, and receives a very rapid backward and forward motion through an eccentric inclosed in a box, B. The fibers are thus placed one upon another, and, in order to prevent them from accumulating, are drawn out by take-off rollers, A, after passing through a very short funnel that has a rotary motion. As the two operations of twisting and winding are effected at the same point, the ribbon will be equally twisted and its formation be more regular.

Fig. 13.—Messrs. Dolfus, Mieg & Co. have patented another arrangement. The cylinder, A, is placed at right angles to the bed, and has quite a large diameter (40 mm.). It revolves in the direction shown by the arrows, through motion transmitted by a cord and pulley. Its velocity can thus be slackened so as to produce a condensation of the filaments. Through its arrangement, the spiral that the fibers form in winding around it is more inclined than the one formed with the cylinder just described. This cylinder, A, enters a short funnel analogous to the one in the Baudouin carder, and which revolves in the same direction.

The tension given the ribbon is less, and is distributed more equally than in the first case, the slidings of the funnel are avoided, and there is greater homogeneousness. A cylinder, B, placed near A, and actuated by the same cord, revolves in an opposite direction, and serves for throwing upon A the fibers that tend to follow the bed, M.—*L'Industrie Textile.*

[Continued from SUPPLEMENT, No. 558, page 8912.]

RADII OF CURVATURE GEOMETRICALLY DETERMINED.

By Prof. C. W. MACCORD, Sc.D.

NO. V.—THE EPICYCLOID, HYPOCYCLOID, AND EPITROCHOID.

LET the circle whose center is C, in Fig. 17, roll upon the one whose center is L, generating the epicycloid

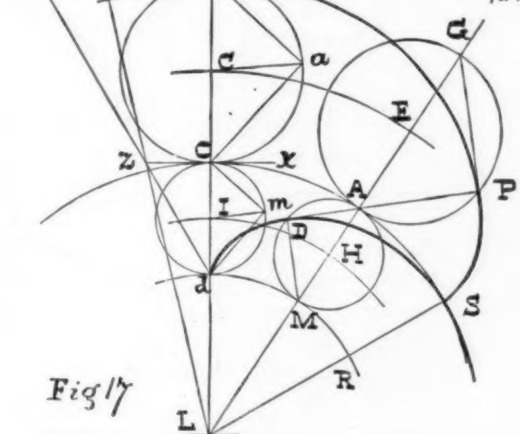


Fig 17

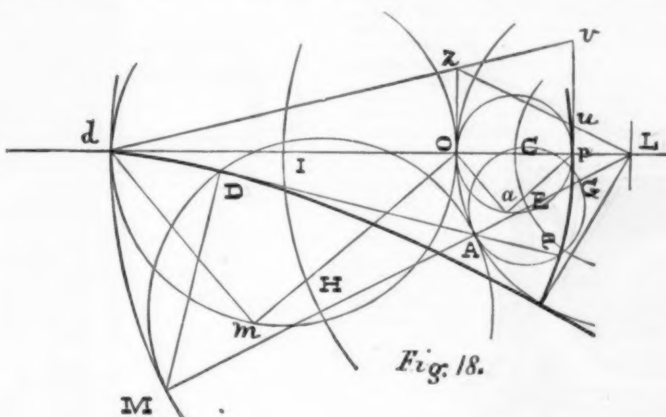


Fig. 18.

p P S. From its analogy to the cycloid, it is apparent that the radius of curvature will be zero at S, and reach a maximum at p. In order to find the value of this maximum radius, we will, for the purpose of avoiding confusion in the diagram, first suppose the

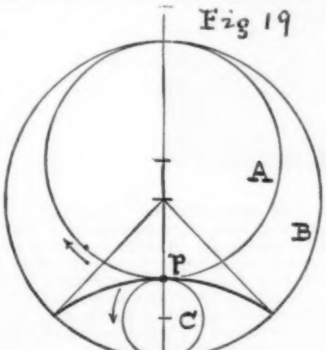


Fig 19

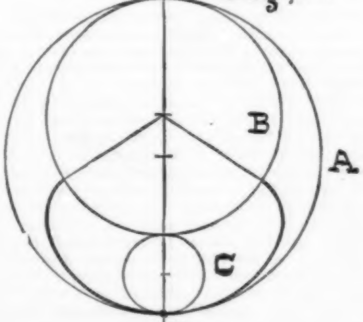


Fig. 20.

generating circle to start from its highest position toward the left. It rotates about C, then against the clock, which causes the point O to move to the right; let O x represent the velocity of this motion. There must then be a contrary and equal motion O z of revolution about L, by which the rotatory component motion of O is neutralized, and the absolute motion of that point in the circumference reduced to zero. Since the revolution affects all points of the generating circle, it will impart to p a motion $p\,u$ perpendicular to p L, of a magnitude determined by producing L z to cut $p\,u$ in u. But the rotation about C causes p to move also to the left, with a velocity equal to O x; therefore, producing $p\,u$ to v, making $u\,v$ equal to O x, we have $p\,v$ as the actual motion of the point p in its epicycloidal path. Now the instantaneous axis O, which is a point in the normal, has an absolute motion O z perpendicular to p L; therefore, drawing $v\,z$ and producing it to cut the normal, we find the intersection d to be the center of curvature of the epicycloid at its highest point p

Now from similar triangles $v\,p\,d$, $z\,O\,d$, we have

$$v\,p : z\,O :: p\,d : O\,d\,;$$

$$\therefore\ v\,p - z\,O : z\,O :: p\,d - O\,d : O\,d\,;$$

or, since $z\,O = v\,u$,

$$u\,p : z\,O :: p\,O : O\,d \quad \ldots\ldots\ldots\ldots (1.)$$

And from similar triangles $u\,p\,L$, $z\,O\,L$, we have

$$u\,p : z\,O :: p\,L : O\,L \quad \ldots\ldots\ldots\ldots (2.)$$

In (1) and (2) the first couplets are identical, whence

$$\frac{p\,O}{p\,L} = \frac{O\,d}{O\,L}, \quad \text{or} \quad \frac{p\,O}{O\,d} = \frac{p\,L}{O\,L}$$

We may write the first of these in the form of a proportion:

$$p\,O : p\,L :: O\,d : O\,L \quad \ldots\ldots\ldots\ldots (3.)$$

whence

$$p\,O : p\,L - p\,O :: O\,d : O\,L - O\,d \quad \ldots (4.)$$

or

$$p\,O : O\,L :: O\,d : d\,L \quad \ldots\ldots\ldots\ldots (5.)$$

From this last it is evident that if we set off the arc d M R equal to the semicircumference $d\,m$ O, the angle d L R measured by it will be equal to the angle O L S; and that if the circle whose diameter is O d roll upon the one whose radius is L d, the point d will describe an epicycloid whose highest point is S. And this curve, d D S, will be the evolute of the original epicycloid p P S. For, drawing the parallel chords O a, $d\,m$, the supplementary chords $p\,a$, O m, and the radii C a, I m, let each circle roll upon its base circle, toward the right, at the same angular rate. Then, when a reaches A, m will reach M, and the centers E and H will lie in the same radial line L M A G. At that instant $u\,p$ will have the position A P, normal to p P S, and making the angle E A P equal to $a\,p$ O, which by hypothesis is equal to d O m. And at the same instant $d\,m$ will have the position D M, normal to the smaller epicycloid, to which the supplementary chord D A is therefore tangent. The angle D A M is therefore equal to d O m, and consequently to E A P, thus making D A P a right line, and establishing the proposition.

From the similar triangles M A D, G A P, we have

$$P\,A : A\,D :: G\,A : A\,M :: p\,O : O\,d :: p\,L : O\,L,$$

whence

$$(P\,A + A\,D), \text{ or } P\,D : P\,A :: p\,L + O\,L : p\,L \ldots\ldots (6.)$$

or, expressing this in words, we have the relation that

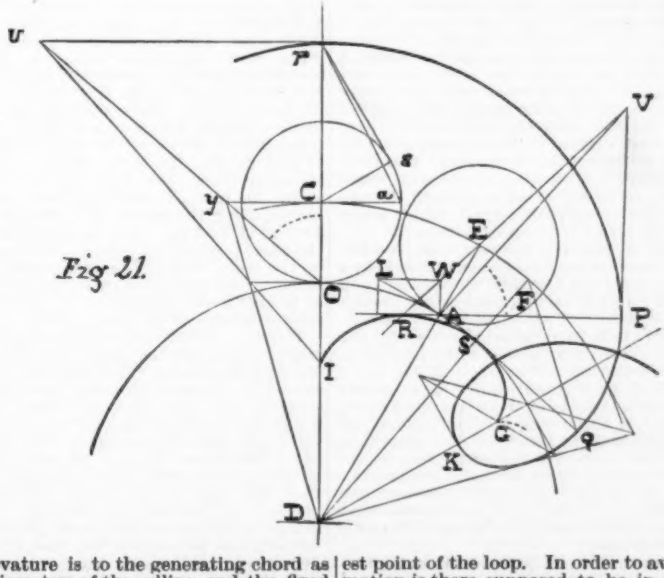


Fig 21.

the radius of curvature is to the generating chord as the *sum* of the diameters of the rolling and the fixed circles is to this *sum* less the radius of the latter.

Similarly, in the case of the hypocycloid, we find its evolute to be another hypocycloid, which lies outside the base circle of the first one, as shown in Fig. 18. This diagram is lettered throughout to correspond with Fig. 17; and the reasoning above given is changed only in these two particulars, viz., that in deriving the proportion (5) from (3), we must write (4) thus:

$$p\,O : p\,L + p\,O :: O\,d : O\,L + O\,d,$$

which gives for (5)

$$p\,O : O\,L :: O\,d : d\,L,$$

as before; and that the rule derived from (6) will now read: "The radius of curvature is to the generating chord as the *difference* of the diameters of the rolling and the fixed circles is to this *difference*, less the radius of the latter."

This wording, it must be noted, applies to the case in which the diameter of the rolling circle is less than the radius of the fixed one. This, however, substantially includes all hypocycloids, for each is capable of two generations; and in Fig. 19, the path of p will be the same, whether it be carried by the small circle rolling in one direction, or by the large one rolling in the other; its curvature diminishes as these two circles approach equality, and at the limit when the diameter of the rolling circle is half that within which it rolls, the hypocycloid becomes a right line.

And, in like manner, the *internal* epicycloid is substantially included among the external ones, each of which may also be generated in two ways. Thus the base circle B (Fig. 20) being fixed, we may suppose the point p to be carried by the larger circle A, whose concave side rolls upon B, or by the smaller one C, rolling upon B in external contact; but its path will be the same in either case.

The epitrochoid is a curve described by a point whose motions are controlled by a circle which rolls upon another fixed circle, the marking point lying either without or within, instead of upon, the circumference.

In Fig. 21, the marking point p lying beyond the circumference, it is clear that the generated curve will form a series of loops, instead of a series of cusps, as in the case of the epicycloids; and it is specifically called the *curtate* epitrochoid. The radius of curvature will be greatest at the highest point p; and in order to determine it, we may proceed exactly as we did in Fig. 17, with due regard to the increased distance from C to p.

The following method, however, is shorter, and might also have been used in treating the epicycloid, the one there adopted being preferred in that case, as leading more directly to the expression of the value of the radius of curvature in comparison with the generating chord.

Imagine C D to be a link pivoted at D, and carrying the rolling wheel upon a pin at its free end C. Let C y be the motion of C, then O z will be the motion of the instantaneous axis, which always lies upon the line of centers. *But* the point of contact O is the fulcrum or center about which p turns at the instant; its motion must then be perpendicular to p O, and of a magnitude determined by producing O y to cut $p\,v$ in v; then $v\,z$ produced cuts the normal in I, the required center of curvature. The same operation is performed to find K G, the minimum radius of curvature at K, the lowest point of the loop. In order to avoid confusion, the motion is there supposed to be in the opposite direction.

Let it be required to find the radius of curvature at any point, as P, of this epitrochoid. About P with

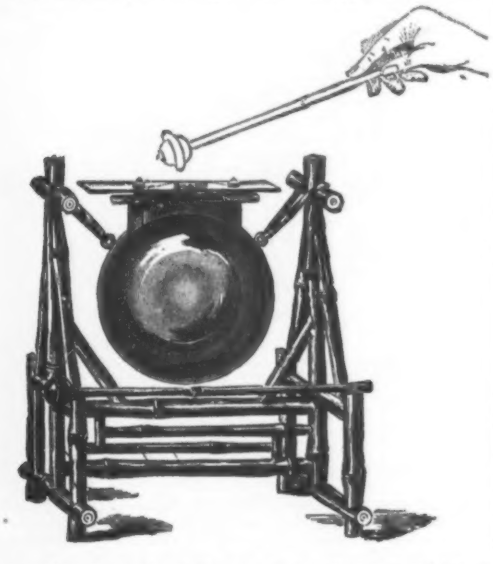
radius p C, describe an arc cutting the path of the center of the rolling circle in E, and draw E D, cutting the base circle in A, the instantaneous axis; then P A is normal to the curve, and, produced, is tangent to the evolute. Suppose the instantaneous axis A to have a motion A L equal to O z, then the angular motion of P about A will be equal to that of C about O; therefore make the angle P A V equal to C o y, and draw P V perpendicular to P A to represent the linear motion of P. A L has a component A W perpendicular to A P, and V W produced cuts the prolongation of P A in R, the center of curvature.

It is quite obvious that P A is the revolved position of a line p a, drawn from the original position p of the tracing point to some point a of the circumference of the rolling circle, and that the arc O a is equal to the arc O A on the base circle. Now, if we draw p s tangent to the rolling circle, and set off the arc O S equal to the arc O s, then s p will ultimately take the position S Q tangent to the base circle, since C s will then be the contact radius F S, and S will be the center of curvature at Q on the curve, as well as the point in which the evolute I R G will be tangent to the base circle.

When the generating point lies *within* the circumference of the rolling circle, the result is the formation of a series of waves instead of loops, and both the curve and its evolute exhibit peculiarities which will be discussed in a succeeding article.

RESONATING GONGS.

THE popularity of the gong for table and hall use is likely to be considerably enhanced by the improvements recently worked out by T. Wilkinson & Sons, Birmingham. The construction consists essentially of a properly shaped resonating chamber with a vibrating metallic plate of sonorous metal or alloy resting across it, the result being a musical note of great breadth and purity of tone. The note is produced by striking the plate downward instead of sideway, as in the case of ordinary gongs, a decided advantage when placed on the tea or dining table. The gongs vary in size from a 2 inch tea gong up to a dinner gong of 3 or 4 feet in diameter, and are mounted on electro-plated bamboo or oak stands, according to size and application. Each



gong has the note of the musical scale with which it corresponds engraved upon it. Sets of two or more gongs forming musical combinations or calls of any required note in the musical scale are supplied to order. In addition to the foregoing, Wilkinson & Sons are preparing to introduce full-sized pianos or "gongchords," in which the new gongs will take the place of strings.

GRINDSTONES.

By JOHN HARDISTY.

IN many workshops, one cause of great loss of time and inconvenience, both to employers and men, is the very bad state in which grindstones are usually worked. They are generally too few in number to meet the requirements of the works, and there is often no one directly responsible to the manager for keeping them in good working condition. As a rule, they are not run quick enough to do good work, and the quicker a stone can be run, within certain limits, the longer it lasts, the truer it remains, and the more work it does in a given time. Also, instead of being supplied with a constant stream of water, the more usual method is to wet the stone either by throwing a canful of water over it occasionally, or by agitating a stick in the water and refuse in the trough—a method which is not only inconvenient, but also wanting in tidiness.

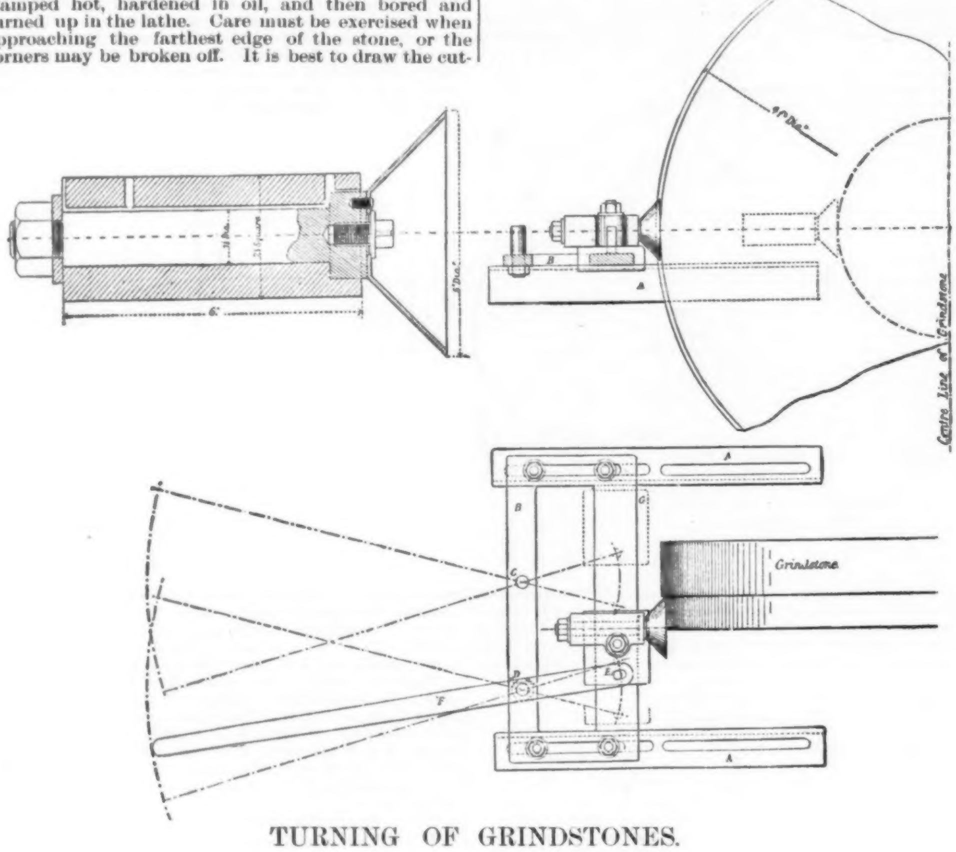
In the first place, it is nearly obvious that, for the sake of economy, there should be so many stones in a shop that the men need not lose time unnecessarily in waiting their turn; and it is unquestionably better practice to have a slide rest attached to the trough, and keep one or more men to grind all the tools for the machines, than to allow each man to grind his own. This arrangement is carried out in a few shops, but is not nearly so general as it ought to be. It is greatly preferred by the men, especially those on piece work, not only on account of the saving in time, but also on account of its cleanliness. It also pays the employer, as there is less time lost, fewer stones will do the work of the place, and the tools, being all ground to a sheet steel gauge, are always sent back to the machines in the best condition for doing good work; and when they again require repairs, can be exchanged for newly ground ones by the grinder.

Another advantage of holding the tools in a rest to be ground is that the stone is kept nearly true, and, therefore, in good condition for grinding chisels, drills, or other tools by hand at the other side.

The most convenient diameter of stone is 4 ft., and this should be run at about one hundred revolutions per minute, with good stream of clean water running on it from an overhead tank or can, fitted with a tap to regulate the supply. The water should be conveyed through an India-rubber pipe, the other end of which is held in the rest, so as to direct the stream of water on to the tool and keep it cold. The stone should be turned up as soon as it becomes about a quarter of an inch out of truth. The old fashioned method of turning the stone while revolving slowly, with a file, is very slow and objectionable, because the stone cannot be used during this somewhat lengthy operation, and its speed has to be considerably reduced in order to enable the file to cut it; and a still greater objection to this plan is the amount of fine grit which flies about and gets into the bearings of the surrounding machinery.

A far better plan is to fix a revolving cutter on the slide rest, which will, in one cut across, make the stone absolutely true, in spite of hard and soft places. This can be done in about three minutes, without altering the speed of the stone, whereas the same effect cannot be obtained in the old fashioned way under about an hour.

The cutter which is found to give the greatest satisfaction is shown below. It simply consists of a rectangular cast iron block, which is held in the rest, and is fitted with a spindle, on one end of which the conical steel cutters can be fastened. When set ready for use, the axis of the spindle should, if produced, pass right through the axis of the stone, and be nearly at right angles to it—the cutting edge should be slightly in advance of the other. It is then set forward at one side of the stone to the depth of the cut required (which should not be more than a quarter of an inch at a time), and moved across its face. The lumps are removed by a sort of wedge action. The cutter, of course, revolves as soon as it comes in contact with the stone, and thus wears away evenly. The cutters are best made from sheet steel, about one-sixteenth of an inch thick, stamped hot, hardened in oil, and then bored and turned up in the lathe. Care must be exercised when approaching the farthest edge of the stone, or the corners may be broken off. It is best to draw the cutter back when half way across, and then start again at the other side, so as to keep the corners good.



TURNING OF GRINDSTONES.

If there is no slide rest on the trough, a simple and effective arrangement for turning the stone may be made as designed by the author, and shown on the right. AA are two angle irons bolted to the trough. B is a steel plate, with the center removed. The front bar then serves as a slide for the cutter, and the back bar carries two studs, C and D, each of which forms the fulcrum for the lever, F. The frame is bolted to the angle irons in any required position, and then for turning the right hand side of the stone the lever is placed on the studs, D and E, and the slide moved across the stone, as shown in plan. For turning the left hand side of the stone, the plate, B, is drawn back, the slide and cutter moved along the bar to the position shown in dotted lines at G, and the plate then put forward and fixed in the same position as before. The lever, F, is then put on the studs, C and E, and the cutter moved on to the stone. The stud is for swiveling the cutter bearing, so as to give a slight clearance to the back of the cutter, whichever side of the stone it may be on.

This is, I believe, the cheapest and simplest arrangement which can be made to turn up any stone by mechanical means. The time of the operation does not exceed six or seven minutes, and then the stone is absolutely true. As the stone wears, the plate carrying the cutter is simply moved further along the slots, as shown on plan representing the stone worn away to 18 in. diameter. It will be seen that one very great advantage of using the simple rest herein described is that the use of two studs, on which the lever is pivoted for turning the two sides of the stone, makes it absolutely impossible for the grinder to break off the corners, and this is not the case where the cutter can be moved right across the stone at one setting; also that the plate, lever, and cutter can all be taken away together and used for turning all the stones in the shop, provided that the angle irons are fixed on all the troughs at the same distance apart.—*Industries.*

THE LAFITTE PROCESS OF WELDING METALS.

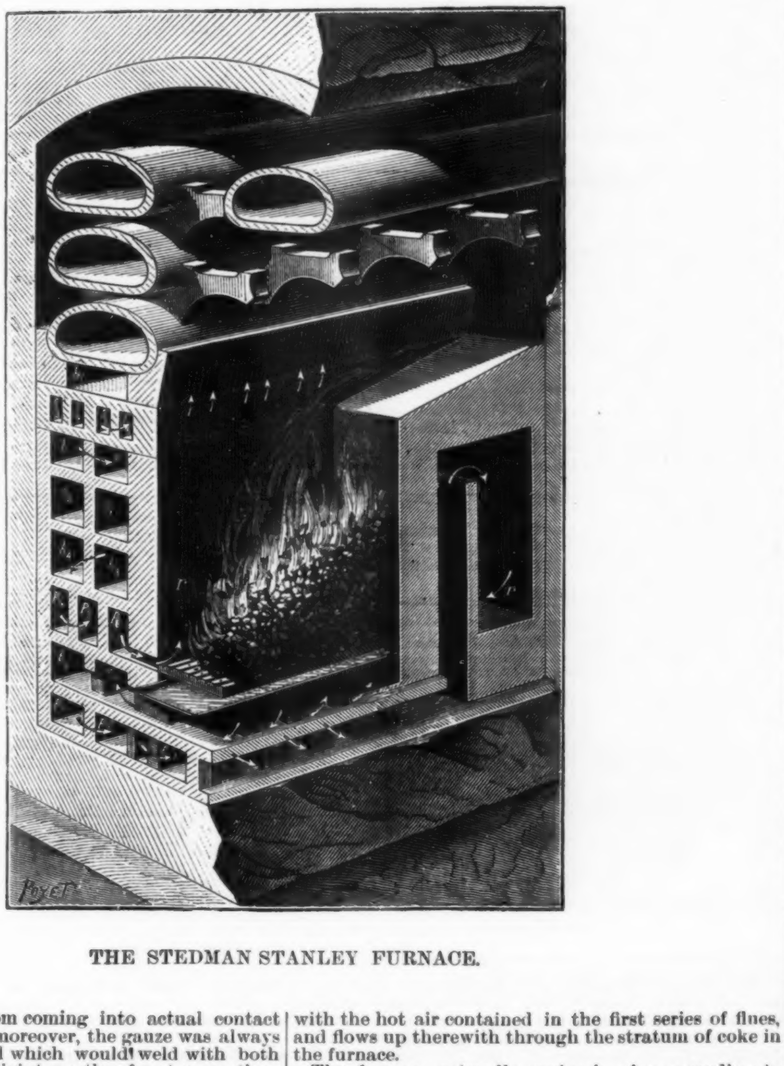
By WILLIAM ANDERSON, M. Inst. C. E.

THOUGH in theory welding iron to iron, steel to steel, or iron to steel, may seem simple enough, it is not always so in practice, and even the best smiths often find the operation difficult and uncertain. If a bar of iron be brought to a high heat out of contact with the air, the metal will prove on examination to have undergone no change. But if this same bar, heated to low white, say 1,300° C., or about 2,400° F., be exposed to the atmosphere, its surface changes color, and it becomes heavier. These results are due to a combination of the oxygen of the air with the iron, and consequent formation of protoxide of iron. Where this oxide presents itself, no weld is possible. Hence the need for finding some means of welding at the temperature at which the least oxidation takes place. This temperature is known to approach the melting point, and is, in fact, the "welding" or "scintillating" white heat, about 2,800° F. At this temperature oxygen has less effect on iron than at any other, possibly on account of dissociation. Very frequently, however, when such a heat is employed, the partial adhesion of the two surfaces gives an unreliable weld; and in addition, when iron is worked at temperatures so elevated, it loses quality, and its elasticity sensibly decreases. In the case of steel these difficulties are augmented. If overheated, it quickly loses some of its carbon, which is absorbed, or rather burnt up, by the oxygen of the air; and this decarburization, more or less complete, is very hard to avoid. Steel, in short, requires careful handling; too high a temperature weakens it, and over numerous "heats" seriously lower its quality. Certain high class steels either do not weld at all, or weld badly, with ordinary methods. Some are so injured by the heat required for welding that they cannot be used, and, generally speaking, cast steel cannot be welded to iron by common methods. The problem for solution, therefore, in welding iron or steel, is how to use a comparatively low heat, and, at the same time, prevent oxidation of the surfaces to be welded. With this object were employed powders, with borax as their base, covering the surfaces and precluding oxidation. M. Lafitte, for instance, produced such a powder, which gave excellent results in many cases; but in others he experienced the difficulty which confronts all powdered fluxes—the difficulty of spreading the powder (the respective components of which had not the same specific gravity) uniformly and evenly over surfaces sometimes very wide, at others narrow, or of irregular shape. Having repeatedly obtained unsatisfactory results, he conceived the idea of making a welding plate which would overcome these drawbacks, and would insure sound, reliable welds. These plates consist usually of thin wire gauze, made of very mild and pliable metal, which forms a supporting medium for the fluxing substance, which, having first been vitrified, is evenly spread over both sides. By its means the flux is uniformly distributed, and owing to its construction and character, it readily adapts itself to all sinuosities of edges or surface. In carrying the invention into practice, the fluxing material is melted and then has dipped into it a sheet of paper, metal, or other suitable material, so as to become coated therewith. This sheet is then passed between rollers, to equalize the coating, after which it is dusted over with the metal filings, and then placed in a muffle, for softening the flux and making the filings adhere thereto. The sheet is then again passed between rollers for equalizing, after which it is ready for use.

The sheet of paper or other material employed serves only as a temporary support for the layer of fluxing material; it may be dispensed with when only small surfaces have to be welded, the agglomerated flux

and filings being in that case formed into a sufficiently cohesive sheet by themselves. For welding together two pieces of iron or steel, a portion of such a sheet is placed between the surfaces to be welded, which are then heated to the required degree and united together by pressure or hammering, thus obtaining a perfect union. The metal sheets employed as supports to the flux may consist partly of iron and partly of copper or nickel, whereby the welding of cast iron with cast iron or with wrought iron or steel, or of nickel with nickel, can be effected. The welding or burning together of melted metals at the time of casting is much facilitated by this process. For this purpose the part of the metal object to be united to the casting is covered with a sheet of fluxing material, and is introduced into the mould, previously heated if necessary, and the fluid metal is then run in the ordinary manner. Complicated forgings are difficult to turn out satisfactorily, but, by the use of the Lafitte plates, they may easily and advantageously be subdivided, their component portions being afterward welded up together into a whole that presents far more solidity than if the forging were worked out of the solid. The plates are now used largely in France for all branches of metal work, machinery, boiler making, edge tool making, fancy ironwork, etc. They are in constant use in the national arsenals at Toulon, Rochefort, Lorient, Brest, and Cherbourg; the gun foundries and small arms factories; the works of the chief railway companies, Creusot, MM. Cail et Cie., and the leading ironworks, etc., throughout the country. They have been severely tested, and the results of the trials conclusively demonstrate the superiority of the plates over other methods.

Mr. Anderson said that the gauze which formed such matrix did not prevent the greater part of the two surfaces to be welded from coming into actual contact with each other, and, moreover, the gauze was always composed of a material which would weld with both surfaces. The resulting joint was thus far stronger than that produced by ordinary welding, where a considerable part of the surface was frequently oxidized. The great feature was that the weld could be performed at a comparatively low temperature. They also had great hopes of success in applying the process to the manufacture of compound armor plates.



THE STEDMAN STANLEY FURNACE.

IMPROVEMENTS IN THE MANUFACTURE OF GAS.

At the meeting of the Technical Society of the Gas Industry, which took place at Paris at the end of last June, much attention was given to the subject of heating gas furnaces. The low price at which coal tar has remained for some months, and the impossibility, in certain countries, of selling this product, even at a very cheap rate, has led to the idea of utilizing it for heating furnaces. An endeavor has likewise been made to use a mixture of coke and coal dusts (which at present have little value) either alone or with tar. The results of these attempts are quite encouraging. It is well to recall the fact that there is nothing new in such use of tar, for it was proposed twenty years ago, before the treatment of benzols had given this product an industrial value. While studying the nature of the fuel to be employed, engineers have likewise occupied themselves with the construction of furnaces and the means to be adopted for obtaining, as far as possible, a complete utilization of the heat produced in the fire-grate. To this effect, numerous solutions have been proposed, and which may be classed in two distinct categories. One of these consists in the direct heating of the furnace with the flames of the fuel, which latter may be broken coke, coke or coal dust, or tar. The other category embraces apparatus in which the carbonic oxide produced in the fire-grate is burned under the retorts. These two, now well-known, systems are frequently applied. They possess decided advantages, and their adoption in gas works depends upon local circumstances and the personal views of the superintendent.

Finally, it is possible, likewise, to combine these two systems, and, in a certain measure, to effect the heating both by the direct caloric from the grate and the combustion of carbonic oxide in the interior of the furnace. An application of this idea is found in the Stedman-Stanley furnace, an American apparatus.

This furnace has been devised for the purpose of utilizing the gases due to combustion, on their exit from the retort chamber, as far as it is possible so to do without too great a modification of the latter's arrangement.

At the moment the gases leave the retort chamber, that is to say, while they still possess a very high temperature, they begin to circulate to the right and left of the masonry, from front to rear, in contact with a series of flues through which flows the air that serves to effect the combustion of the carbonic oxide under the retorts. After this, they heat the air designed for the combustion of the coke in the furnace, and finally flow under the ash box. Here they effect the vaporization of the water necessary to prevent the fouling of the grate and to reduce the excess of heat, which, without such precaution, would exert an injurious influence upon the inner surfaces of the fire chamber. As soon as the steam rises above the ash box, it mixes with the hot air contained in the first series of flues, and flows up therewith through the stratum of coke in the furnace.

The furnace naturally varies in size, according to the nature of the service required of it and the arrangement of the building in which it is located. However, its height ought not to be less than 3½ feet, if it be desired to obtain gaseous fuel. The deeper that it is, the more uniform will be the composition of the gaseous mixture furnished by the generator, and the more advantageous will be the results.

The retorts, six in number to each furnace, measure internally 13 in. × 26 in. × 9 ft. The first Stedman-Stanley furnaces were built in America at the close of 1884, and for a few months the maneuvering of them was attended with a certain number of interruptions, as always happens when new apparatus are set running. But since then the manufacture has been rendered regular, and is now giving good results. During the month of June, 1885, for example, there were distilled 969,230 pounds of coal, which yielded 5,235,660 cubic feet of gas. The mean yield is 11,900 cubic feet per ton of coal. The mean charge of coal per retort is 325 pounds. The average daily production of gas per retort is 10,575 cubic feet, and per furnace, 63,470 cubic feet. These results were obtained from distilling Westmoreland coal with 4 per cent. of West Virginia cannel. The gas produced had a mean intensity of 19·5 candles in a trial made with an ordinary Argand burner.

The furnaces are easily maneuvered, and convenient to inspect, and, with a little care, may be prevented from choking up. If a supply of water be kept up continuously in the ash-box, the furnace will need cleaning only every five or six weeks; but if the box be left dry, clinkers will rapidly accumulate, and take but an hour or two to smother the fire. The role of the steam in this case we have explained above. When the furnace becomes choked up, it is necessary to draw out the grate bars and allow the fire to drop.

The mass of clinkers is found to be in a pliable state, that permits of its being broken into bits without trouble, and detached from the sides of the furnace. After three hundred days' service, the furnaces, owing to this fact, have been found to be in almost as good a state as they were at the beginning, and no necessity of changing the grate bars had arisen.

According to the information that we have received, the service presents no difficulty. Coke is taken from the two retorts at the bottom and thrown directly into the furnace, so that the heating absorbs nearly twenty-five per cent. of the coke production. One man can, without trouble, superintend seven different furnaces. All that he needs an assistant for is to do the cleaning and to remove the clinkers—an operation that takes but three-quarters of an hour per furnace. The stoker pokes the fire every four hours, removes the ashes, sees to it that the water does not give out, and helps to carry the coke into the yard, where, with another laborer, he extinguishes it.—*La Nature.*

ON THE PROGRESS AND DEVELOPMENT OF MARINE ENGINEERING.*

By WILLIAM PARKER, Chief Engineer-Surveyor, Lloyd's.

At a meeting of the Institution of Mechanical Engineers, held in this city in 1872, Sir F. J. Bramwell read a very interesting paper "On the Progress effected in the Economy of Fuel in Steam Navigation, considered in Relation to Compound Cylinder Engines and High Pressure Steam."

In this paper the history of the marine engine was traced from 1817 down to 1872, and it was shown that, during the last nine years of that period, the economy effected in the mode of making steam by the introduction of surface condensation, which obviated the direct waste of heat necessitated by continuously brining or blowing off part of the water from the boiler, combined with that resulting from the greater degree of expansion rendered possible by the adoption of compound engines working with higher steam pressures, had reduced the consumption of fuel in proportion to the power developed by more than one half, or, in other words, during the period from 1863 to 1872, our marine engineers had doubled the working efficiency of the marine steam engine.

The immediate result of the great step in economy then attained was a large development of steam shipping, steamers being able to be profitably engaged in trades from which they were previously shut out, while larger and more powerful steamers took the place of the older ones on the passenger lines, and in the other trades in which steamers had previously been employed.

During the discussion on Sir F. Bramwell's paper the late Sir William Siemens, who was then the President of the Institution of Mechanical Engineers, said that, in his opinion, any further advance in economy should be looked for rather in the method of producing the steam than in further extending its expansive action. This opinion, however, has not been justified by events, as a further considerable advance in economy has already been attained by improvements in the methods of using steam, while little, if any, improvement has been made in the methods of producing it.

In 1881, Mr. F. C. Marshall, of the firm of Messrs. R. W. Hawthorn, Leslie & Co., of Newcastle-on-Tyne, read a paper at a meeting of the same Institution, at Newcastle, "On the Progress and Development of the Marine Engine," in which it was shown that since the reading of Sir F. Bramwell's paper, a further economy of 13·3 per cent. had been effected, the advance being wholly due to the use of higher steam pressures.

Since that time a still further improvement has been made by the introduction of even higher steam pressures, and of triple and quadruple expansive engines, for the proper utilization of these higher pressures; but up to the present little, if any, improvement has been effected in the method of making the steam, the marine boiler of the present day being almost exactly what it was in 1872, except, of course, that it has been possible to make it stronger than was then deemed to be practicable, owing to our having command of improved materials and appliances.

It is, of course, difficult to foresee what the future has in store for us, or to be sure of anything, except that there is no finality in invention; but, in my opinion, there are good reasons for believing that, so far as the use of steam is concerned, that is to say, the conversion of the heat of the steam into work by means of the engine itself, there is not now so much room for improvement as there appears to be in the other operations of transferring the heat of the combustion of the fuel into the steam, or of applying the work of the engine, when it has been produced, to its useful purpose of propelling the vessel. A very considerable portion of the heat of combustion of the coal still disappears up the funnels of all our steamers, doing no useful work, except producing the necessary draught, which could be produced mechanically with very much less heat, if only the funnel heat could otherwise be usefully employed; while there still remains a wide field for improvement by the production of more nearly perfect combustion of the fuel in the furnaces themselves.

The introduction of steel as a material for boiler plates, and the use of a stronger form of furnace than the plain cylindrical one, combined with improvements in manufacture, have now admitted of steam pressures of 150 lb. to 180 lb. per square inch being safely carried in boilers of the ordinary type, so that there will be now no incentive for engineers to design these novel types of boilers so far as strength is concerned, unless it can be shown that there is reasonable ground for supposing that steam of still higher pressures, viz., from 250 lb. to 300 lb. per square inch, can be conveniently and economically used. I shall return to this point further on, but in the mean time I must express my conviction that if we find in the immediate future, in regard to boilers, any departure from our present practice, the step will not be made solely on account of obtaining higher steam pressures, but will be made

* Read at the twenty-seventh session of the Institution of Naval Architects, at Liverpool.

principally, if not entirely, with the view of obtaining greater evaporative efficiency.

The first engines made for sea-going purposes on the triple expansive principle were those made in 1874 from the designs of Mr. A. C. Kirk, now of the firm of Messrs. R. Napier & Sons, for the S.S. Propontis, owned by Mr. W. H. Dixon, of this city. These engines were made with three cranks, and were supplied with steam by means of one of the types of boilers I have mentioned, viz., Rowan's patent, and during the limited time that the boilers worked satisfactorily they proved themselves to be very efficient. Unfortunately, the boilers failed, two out of four having exploded disastrously at sea. They were replaced by others of the ordinary type working at what was at that time considered to be a very high pressure, viz., 90 lb. per square inch; and the engines, of course, did not give quite such good results at that pressure as they had done at the pressure for which they were designed. This, however, was not their fault, and I believe they are still at work and are giving great satisfaction, being now supplied with steam of 160 lb. pressure from another set of boilers. These engines should, therefore, be regarded with great interest as being the parents of what is now becoming the common engine of the day.

The next triple expansion engines were those of the yacht Isa, designed by Mr. A. Taylor, of Newcastle-on-Tyne, and built in 1877. These were constructed to work upon two cranks only, the high and intermediate cylinders being tandem. They were supplied with steam of 120 lb. pressure, from a boiler of the ordinary type, the comparatively small dimensions of the boiler enabling this pressure to be carried without difficulty. These engines were very successful, but seeing that they were fitted in a yacht, and were, therefore, not working continuously, and were, moreover, of comparatively small power, they did not excite so great an interest in the engineering world as might have been expected, and it was not until 1881 that the problem of economic propulsion advanced a further stride by the Aberdeen, built for Messrs. G. Thompson & Co., of London, showing conclusively that the triple expansion engines were capable of working continuously on long ocean voyages with complete satisfaction.

The engines of the Aberdeen were made by Messrs. R. Napier & Sons, after the general design of those of the Propontis. They are supplied with steam at a pressure of 125 lb. per square inch by two steel double-ended boilers, each 14 ft. in diameter, and they have until now worked regularly and satisfactorily upon the longest voyages, and have given no trouble whatever, beyond the ordinary wear and tear incidental to engines of the same power, the high steam pressure involving no more difficulties either with the boilers or engines than would have been experienced with a pressure of 75 lb. or 80 lb. per square inch, working under the same conditions.

Since the Aberdeen commenced running, there have been at least 150 sets of triple expansion engines made for the British mercantile marine, while about 20 sets of ordinary compound engines have been altered into triple expansion when they have had new boilers fitted to them.

During the present half year, there have been no less than 41 sets of triple expansion engines built, as compared to 60 pairs of compound engines, and there are at present 128 sets of triple expansion engines building, as compared to 71 pairs of compound, independently of those building for the British and foreign navies. For the British Royal Navy there are 20 sets being built, expected in the aggregate to indicate 130,000 horse power.

It is difficult to obtain absolutely reliable information as to the performances of these vessels, but the above statement is, I think, conclusive proof that the economy obtained by using this type of engine, instead of the two cylinder compound, is very appreciable, otherwise it is difficult to account for the very rapid rate at which the new type has superseded the other in practically all new vessels. I can, however, give the following particulars of the actual work done by some steamers fitted with triple expansion engines, and others that have been converted from ordinary compound engines to triple expansion engines. These particulars, having been obtained from reliable sources, speak for themselves.

Two large passenger steamers of over 4,500 gross tonnage, having engines of about 6,000 indicated horse power, built of the same dimensions, from the same lines, with similar propellers, are exactly alike in every respect except so far as their machinery is concerned. One vessel is fitted with triple expansion engines working at a pressure of 145 lb. per square inch, while the other vessel is fitted with ordinary compound engines, working at a pressure of 90 lb. per square inch. Both vessels are engaged in the same trade, and steam at the same rate of speed, viz., 12 knots per hour. The latter vessel, on a round voyage of 84 days, burns 1,200 tons more coal than the former.

The performances of the next two vessels I am about to quote do not compare on a question of decreased consumption, but one of enhanced carrying capacity, with an equal speed and the same consumption of coal.

The first vessel has a gross tonnage of about 2,220 tons, and is, comparatively speaking, a modern type of ship. She is fitted with ordinary compound engines, working at a pressure of 90 lb. per square inch, and carries, when fully loaded, 3,000 tons of cargo, including bunker coal. She steams 10 knots per hour, and burns 20 tons of coal per day. The second vessel has a gross tonnage of 2,800 tons, was built last year, and fitted with triple expansion engines, working at a pressure of 150 lb. per square inch. She makes the voyage to India in the same length of time as the former vessel, burns the same amount of coal, viz., 20 tons per day, and carries 4,200 tons, or 1,200 tons more cargo, with the same working expenditure.

The next case I will take is that of a mail steamer, the engines of which have been converted from ordinary compound to triple expansive, the propeller not being altered. The vessel is of 3,500 tons gross register, both ship and engines having been built by one of our leading builders. She was originally fitted (in 1871) with ordinary compound engines, working at a pressure of 60 lb. per square inch. These have been altered into triple expansion engines, and new boilers have been fitted, working at 150 lb. per square inch. The vessel still maintains her original speed, and the consumption of coal has been lessened 25 per cent.

In the case of another mail steamer, the engines of which have been altered in a similar manner, I have compared her present performances with those of ten previous voyages, and find that the decrease in consumption is 33 per cent., while the same speed is maintained.

In these cases the consumption quoted includes the coal used for galley, steering engine, and other purposes, so that the economy gained in the main engines is greater than that given by these figures.

It will thus be seen that during the last five years marine engineers have not been idle, for even if we do not consider the full gain of 33 per cent. which is usually claimed to have been fully demonstrated, but merely acknowledge an economy of 25 per cent. as having been attained, it will be evident that the fact that 3 tons of coal are now able to do the work which it used to require 4 tons to perform, will have an important influence upon the future of our steam shipping. And I venture to predict that shipowners will not be slow in availing themselves of the opportunity that engineers have provided for them, and that we shall shortly see very many of the engines of our commercial marine, which are in good condition, converted into the newer type.

This conversion may be made in at least three different ways: 1. By adding another cylinder and crank, necessitating an addition to the bedplate, and therefore also to the length of the engine room. This method will most probably in all cases necessitate the removal of the present cylinders and the fitting of three new ones of proper proportions. 2. By adding another cylinder to the top of either the present high or of the low pressure cylinder, necessitating no great structural alteration to the engines, but possibly requiring the present low pressure cylinder to be fitted with a liner to somewhat reduce its diameter. 3. (And this is the solution of the problem most favored by many engineers.) By replacing the two present cylinders by four new ones, thus making a tandem arrangement to each crank, and converting the engine into one of the quadruple expansion type.

Whichever method is adopted, it must be remembered that the economy obtained in the triple expansion engine is not obtained by merely making the steam work successively in three cylinders irrespective of other considerations. The economy is obtained primarily by utilizing the principle of expansion to as great a degree as is practicable; but, as I pointed out in a paper "On the Economy of Compound Engines," which I read before the members of this Institution at London, in March, 1882, there must be a limit to which expansion can be beneficially carried in two-cylinder engines, on account of the condensation of the steam in the cylinders, induced by the great range of temperature to which they are continually being subjected, and there is consequently a similar limit to which it can be economically carried in triple-expansive engines. Any further increase of expansion beyond this will necessitate the use of four cylinders, if it is to be carried out economically.

There is, however, another point as to expansion, which deserves consideration. It is in not carrying expansion to a sufficient extent, and so discharging the steam into the condenser before it has effectively done its work. This matter, if not specially pointed out, is likely to deceive the uninitiated, who would perhaps conceive an engine so working to be a better one than another of superior design, simply because it would be doing a greater amount of work in proportion to its size.

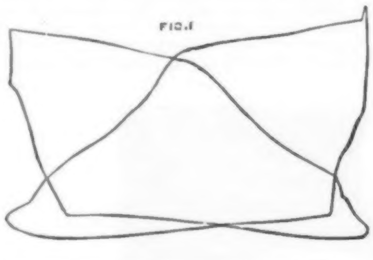
In order to fully utilize the principle of expansion, it is necessary to have engines of sufficient size for the steam to fully expand into, and so relatively large engines will be, within proper limits, more economical than smaller ones doing the same amount of work. To show this, I will refer to the performances of two engines on their trial trips made by two well known engineering firms, who have each attained celebrity for the excellence of their productions, yet a comparison of the results obtained in the two cases shows a marked difference between the two engines. In engine No. 1 the cylinders are proportioned as 1:2·5:7·11; the boiler pressure is 150 lb. per square inch, and the mean pressure of the three cylinders, reduced to the low pressure cylinder, is 25·61. In engine No. 2 the cylinders are proportioned as 1:2·5:5·28, the boiler pressure is 135 lb. per square inch, and the mean pressure, reduced to low pressure cylinder, is 32·10 lb. per square inch. Engine No. 2 did not use the steam so expansively as engine No. 1, and in proportion to the size of low pressure cylinders it did $\frac{32·10}{25·61}$, or 1·253 times as much work as No. 1. On measuring the amount of steam used per revolution, as shown by the indicator diagrams, it was found, however, that engine No. 2 used 1·494 times as much weight of steam as engine No. 1; and as it was only doing 1·253 times as much work, the efficiency of No. 1 engine must be $\frac{1·494}{1·253}$, or 1·19 times greater than that of No. 2, in other words No. 1 engine would give 19 per cent. more power than No. 2, from the same weight of steam used.

I am aware that these figures cannot all be taken as being mathematically correct, for, as I pointed out in the paper referred to, there must always be some condensation of steam in all engines, so that a greater weight of steam is used than can be measured upon the indicator diagrams, and no doubt there is somewhat greater condensation in engine No. 1 than in No. 2; but the difference from this cause cannot nearly be so great as 19 per cent., so that it remains that one engine is very much more economical than the other. It may perhaps be simpler to say that engine No. 2 is being overworked.

To show more clearly the effect of the internal or cylindrical condensation upon the efficiency of the engine, it will perhaps be interesting to refer to the annexed diagram. It is known from theoretical considerations that, supposing no practical difficulties intervened to prevent its realization, the utmost efficiency possible with a steam engine would be represented by the difference between the temperature of the boiler steam and that of the condenser, divided by the absolute temperature of the boiler steam. This ideal efficiency for steam of various pressures, assuming, as is usual, the condenser temperature to be 100 deg., is shown by the curved line in the figure. It will be seen to rise slowly as the pressure increases, being 0·261 at 50 lb., 0·270 at 60 lb., 0·298 at 100 lb., 0·321 at 150 lb., 0·339 at 200 lb., 0·353 at 250 lb., and 0·365 at 300 lb. per square inch.

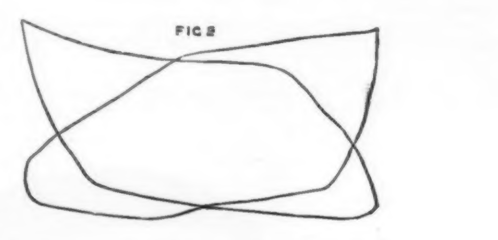
The actual efficiencies of steam engines, in practice, must, for several reasons, always be considerably less

FIG. 1



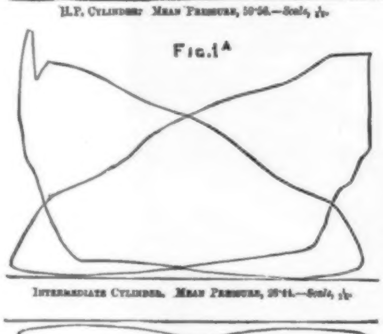
H.P. CYLINDER. MEAN PRESSURE, 59·56.—*Scale*, 1/40.

FIG. 2



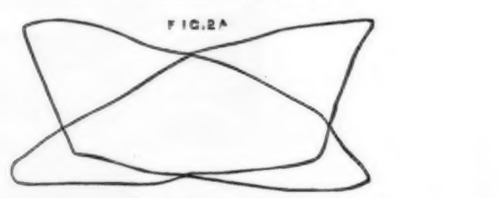
H.P. CYLINDER. MEAN PRESSURE, 52·7.—*Scale*, 1/40.

FIG. 1A



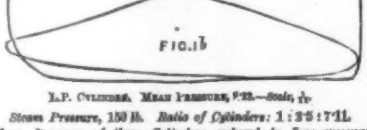
INTERMEDIATE CYLINDER. MEAN PRESSURE, 29·44.—*Scale*, 1/16.

FIG. 2A



INTERMEDIATE CYLINDER. MEAN PRESSURE, 21·2.—*Scale*, 1/16.

FIG. 1b

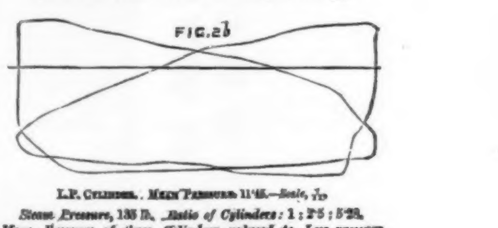


L.P. CYLINDER. MEAN PRESSURE, 7·23.—*Scale*, 1/12.

Steam Pressure, 150 lb. *Ratio of Cylinders*: 1 : 2·5 : 7·11.

Mean Pressure of three Cylinders reduced to Low-pressure Cylinder, 25·61 *lb. per square inch.*

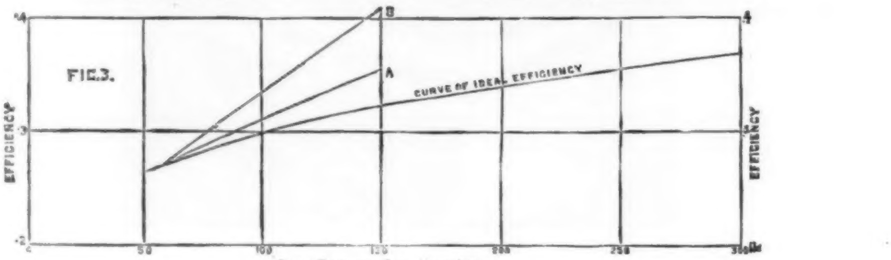
FIG. 2b



L.P. CYLINDER. MEAN PRESSURE, 11·45.—*Scale*, 1/12.

Steam Pressure, 135 lb. *Ratio of Cylinders*: 1 : 2·5 : 5·28.

Mean Pressure of three Cylinders reduced to Low-pressure Cylinder, 32·10 *lb. per square inch.*



Steam Pressures above Atmosphere.

than these figures indicate; the principal one being the inevitable condensation in the cylinders. If, however, the various elements contributing to the reduction of the actual efficiency below its theoretical maximum amount be proportional to the work actually done in the steam engine, the form of this curve will still represent the relative efficiencies of engines working with the different steam pressures. From this we see that in advancing from 60 lb. pressure to 150 lb., we ought to increase the efficiency by 19 per cent., or, what is the same thing, to effect an economy of 16 per cent. The fact that an increase of economy is actually obtained considerably above this amount, when using the triple expansion engine, shows that this engine is working under conditions more nearly approaching to those required for the maximum efficiency than the other, and I think proves pretty conclusively that the reduction of the internal condensation by the lessening of the range of temperatures of the surfaces exposed to the steam has more than counterbalanced the loss due to the reduction of effect by the increased wire-drawing and unbalanced expansion incidental to the application of an extra cylinder, slide valve chest, etc. It is possible that a still further effect in this direction may be obtained by using four cylinders instead of three, but experience on this point is wanting at present.

The spot A in the figure lying above the curve represents the height to which the efficiency has gone in starting from 60 lb., if 25 per cent. economy has been effected, while the spot B, still further above the curve, shows the similar height upon the assumption of an economy of 33 per cent.

I have previously referred to the probability of our being able to use still higher pressures in the immediate future. Of advance in this direction I am not very hopeful for several reasons; but, in face of the advance recently made, it would be rash to be too positive. It must be remembered, however, that every addition to steam pressure increases the temperature of the steam. At 150 lb. the temperature is 366 deg. Fah., at 300 lb. it is 422 deg. When it is remembered that the boiler plates which have to transmit the heat to the water must necessarily be hotter than the steam temperature, and that steel is considered to be unreliable when it is at what is called the blue heat, which commences at about 470 deg. Fah., it will be evident that at a pressure of 300 lb. there will be less than half the margin between the steam temperature and the temperature of unreliability of the plates than there is at a pressure of 150 lb. per square inch, and only one-third of the margin there is at 80 lb. pressure.

Further, an increase of steam temperature will probably be felt in the working of the engine itself, as there must be some limit of temperature at which the endurance of cast iron will cease, and we may be nearer that limit we think. I believe that our friends, the locomotive engineers, found a limit of this kind in their cylinders at lower pressures than we are now working at, until they changed the method of casting them. There is the further consideration that as the higher pressures advance, the less margin there is to work upon in that direction, as is evidenced by the tendency to flatten itself shown by the efficiency curve in the diagram.

Turning now to the question of the boiler, I have stated that we are practically using the same design of steam generator as was common in 1871, but there are at present several attempts being made in the direction of economy in fuel.

As regards the production of large power upon the minimum of weight and space, where full economy is a secondary consideration, I have only to mention the wonderful performances of the boilers now being fitted in torpedo boats, to show that enormous progress has recently been made, but these boilers are necessarily unfit for ocean steaming purposes. The application of forced draught also, in the Royal Navy, to boilers of the ordinary type, with a somewhat similar object in view, has considerably augmented the power of our war vessels, without adding greatly to their weight or cost, but here also economy of fuel is not the prime consideration. Forced draught has, however, been applied in merchant steamers with a view of lessening the dimensions of the boiler. This is rendered possible by the increased temperature of the fire being able to transmit more heat per unit of surface, and to render the boiler, surface for surface, more efficient than it would be if a lower fire temperature were used. It is evident that if the boiler surfaces are more efficient, less heat will be wasted up the funnel.

Another question which forced draught has satisfactorily solved is the use of small and inferior coal. There is at least one British and there are several Italian steamers now running, with very satisfactory results, burning nothing but very inferior coal, which could not possibly be burned with natural draught with the ordinary fire bars. By employing suitable bars, and closing in the ash pits, most perfect combustion is obtained; and it is claimed that even when comparing weight for weight of coal used, there is a decided economy in this system, since there are no ashes left unconsumed, while of course, considering the low price of dust coal as compared with ordinary steam coals, a large saving of cost is being effected.

MINERAL OIL FUEL.

I cannot conclude this paper without a reference to what is deemed by some to be the fuel of the future. I refer, of course, to "mineral oil." Since 1856, and up to the present time, this fuel has been successfully used for marine purposes on the Caspian Sea, a region where oil is remarkably cheap and where coal is expensive. The local conditions are thus extremely favorable for the use of oil, and it is the question of cost which will ultimately settle the problem whether oil or coal is to be the fuel used in any region.

In every case in which oil has been successfully used up to the present time as a fuel for boilers, it is blown into the furnace and at the same time converted into a spray (or pulverized, as it is technically called) by means of a steam jet, this jet being obtained from the boiler itself. The amount of steam used for the purpose of pulverization has, I believe, never been definitely ascertained, but it is variously estimated at from 8 to 12 per cent. of the total production of steam in the boilers. Let us assume for a moment that it is 8 per cent. This will mean that for every 92 tons of water evaporated for use in the engine 8 tons of fresh water is lost, and must be supplied from the sea. If this is supplied from the main boilers, this will mean that a steamer exerting, say, 1,000 indicated horse-power will require 14 tons of sea water to be put into the boilers per day. What amount of scale this will produce I will leave others to calculate, but it is evident that such a system is wholly impracticable for extended ocean steaming. It is, of course, possible to use an auxiliary boiler working at a comparatively low pressure for the purpose of feeding the oil into the furnace, but this complication is not likely to be carried out.

When, however, the price of oil falls so low as to render it possible for it to compete with coal in ocean work, I do not doubt that it will be easy to find means to burn it, without employing steam to "pulverize" it. I believe the ultimate solution of the problem will be found in the use of compressed air, possibly of heated air, for the purpose of pulverization.

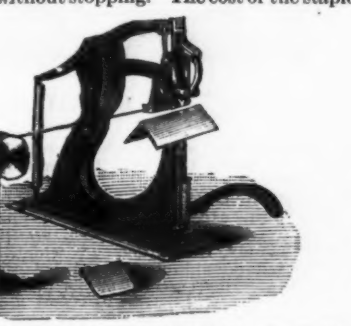
WIRE STITCHING MACHINE.

As soon as it was evident that pamphlets and journals could be so easily and rapidly stitched with wire by machine, instead of the less satisfactory hand sewing, a number of machines were placed on the market for this purpose, and of the lower priced ones it may be said that they were wholly made to use staples already formed, thus ⌐¬, which were placed on a suitable bar, and fed into the machine, which stabbed them through the paper and closed them. A successful attempt to produce a cheap and efficient machine for making its own staples from a reel of wire appears to be that illustrated above.

This particular design is adapted for feeding in the paper from the side, so that any length of pamphlet may be stitched; but there is also another design for a front feed, in which all the mechanism is reversed from below to above. The iron table and the wire reel are placed at the back; the latter, in the illustration, is at the right hand side on the wooden table. The wire passes from this to the ingenious machinery under the V table, where it is cut off to length, bent into the form of a staple, and stabbed through the paper; the top arm then descends and closes the ends of the staple over, the whole machine being driven by a treadle motion.

In ordinary working, a machine of this type sews pamphlets at the rate of 1,600 stitches per hour. The reels carry enough wire to make 25,000 staples of No. 26, 20,000 of No. 24, and 15,000 of No. 21 wire, so that the machine can run off that quantity without stopping, instead of making a somewhat lengthened stop about every 250 stitches to insert a new lot of staples, as is necessary in the ready-made staple machine. This also prevents the usual great loss of staples, amounting to an average of 10 per cent., during the process of unpacking and filling. The large designs are made to stab through a maximum thickness of $\frac{5}{16}$ in.

The smaller machine illustrated is the outcome of a demand for a specially cheap and small machine for country offices, and seems quite as efficient as the larger one when stabbing through sheets up to $\frac{3}{16}$ in. thick, which is considered its limit. The mechanism is very similar to the large machine, but is worked by hand. The handle is shown in the illustration projecting from behind the machine to the right. It works with particularly thin wire, if required, even thinner than usually employed, and will work off 20,000 staples without stopping. The cost of the staples by this method is from one-fourth to one-sixth that as compared with those ready made. These machines are also arranged for stitching card and wood boxes.—*Industries.*



WIRE STITCHING MACHINE.

THE FASTEST SEABOAT IN EXISTENCE.

THE fastest seaboat in existence has been delivered recently by Mr. F. Schichau, of Elbing, to the Chinese Government. She is a so-called ocean-going torpedo boat, built according to a new model, and has given the greatest satisfaction on trial. The introduction of this type will therefore soon come into more general use.

The boat is 45 meters long, 6 meters broad, has an engine of 1,500 I. H. P., built according to Mr. Schichau's triple-expansion system, and reaches with full equipment and coals for 1,000 sea miles at 10 knot speed on board, a speed of 24·5 knots per hour.

The whole steam power is created in only *one* boiler, a fact which also stands alone up till now in the history of engineering, and certainly will produce some modifications in future marine engineering. The result is due partly to the special construction of the boiler, partly to the Schichau patent ventilating and firing apparatus, whereby it is possible to create in a boiler of moderate dimensions such a large amount of steam power.

The total power of 1,500 I. H. P. is transmitted to a single screw of only 2,2(0 $\frac{\text{m}}{\text{m}}$ diameter, and so fully utilized by it that the slip at full speed is almost *nil.* This also is a result never yet reached.

There are solved, therefore, three problems in this boat, which up till now have baffled the ingenuity of the most advanced engineers, and often been proclaimed as impossible to reach.

1. A speed of 24 knots continued for several hours.
2. Construction of one boiler for 1,500 I. H. P.
3. Construction of an effective screw of about two meters diameter for this power.

Mr. Schichau by solving these problems has made again a good step forward in the field of naval architecture and marine engineering, so long honorably occupied by his firm.

The trials of the boat took place in the beginning of June, at Pillau, in the open sea, and consisted in several runs on the measured mile, and long runs for three and six consecutive hours. The exact dates of these trials are the following:

1. With full equipment and coals for 1,000 sea miles at 10 knots on board. Speed on the measured mile, 24·5 knots; mean speed on long run, 24 knots; revolution of engines, 325·330 per minute. Wind strong, force 3-4, sea rather moved.
2. With full equipment and full coal bunker (coals for about 3,000 sea miles), mean speed on long run 22·5 knots; revolutions, 318·320. Wind light, force 2, sea moved.
3. Coal trial at 12 knots speed, revolutions, 160; 60·65 kilog. coals per hour.

Steam pressure on all trials, 12 atm.; vacuum, 0·9-0·95.

The whole machinery, as usual in Mr. Schichau's practice, worked faultlessly from the first to the last moment. The Commission expressed their congratulations and satisfaction at the results obtained, which far surpass the conditions of the contract. The boat left Pillau with her own crew through the Mediterranean and Suez to China.

H. P. cylinder, 418 I.H.P.; M. P. cylinder, 475 I.H.P.; L. P. cylinder, 483 I.H.P.; total, 1,376 I.H.P.

Diagrams, steam pressure, 12 atm.; vacuum, 0·95; revolutions, 320; speed, 24 knots.

THE STAMPEDE PASS TUNNEL ON THE NORTHERN PACIFIC.

A CORRESPONDENT of the St. Paul *Pioneer Press* gives the following account of the tunnel now under construction through the Cascade Mountains in Washington Territory, on the Northern Pacific Railroad:

The present location of Stampede Tunnel was definitely decided upon about a year ago. It is one mile south of the pass where the course of Mosquito Creek on the east and Camp Creek on the west form depressions in the mountain at an elevation of 3,837 feet. When finished, the tunnel will be 9,850 feet long, or nearly two miles—the longest in the country, except, perhaps, the Hoosac. The contract was given to Nelson Bennett, Jan. 22, and he appointed his brother, S. J. Bennett, to superintend the work, and instructed him to proceed at once into the mountain with men and material to begin operations. Fifteen men composed Bennett's party, which began to climb the mountain on Feb 5 in the face of ten feet of snow, and on Feb. 13 the first blast echoed through the dense forests of the Cascades, and the wild beasts that had held undisputed claim for all time prior to that echo stood still in wonder, preparatory to their hasty retreat before the advance of civilization. Mosquito Creek, in its course down the mountain, dropped directly over the portal of the tunnel, and flumes had to be constructed and made fast above the work to divert the stream and facilitate the labor. Then four immense boilers and engines were dragged up the mountain on skids over a road that a single horseman finds difficulty in traveling. With these operating improved drills, the addition of more and skilled workmen as the weather opened up, the introduction of two Ingersoll air compressors, the tunnel is being made at the rate of between 11 and 13 feet per day. The rock is blasted every six hours, and the result loaded, by gangs of men, into cars and drawn out at the rate of 100 cubic yards per day. Blacksmith and machine shops have been erected in the vicinity of the portal, the compressed-air pipes being tapped to furnish combustion at the furnace and blacksmith fires. In a large tank into which the water

of Mosquito Creek is turned are four receivers, weighing 6,000 pounds, that yet have to be held at the bottom of the tank by braces to prevent their rising to the surface. The air is forced into these by the compressors for purification, and conducted thence into the tunnel through rubber pipes to the drills, which are clamped to large jacks, made of 6 in. iron pipe and braced by the screws of the jack from the upper bench of the tunnel to the roof. The drills are operated with an average dry air pressure of 60 pounds. The smoke of the blasts is conducted from the tunnel by a large wooden flue, 28 by 30 in., braced along one side of the tunnel, while along the other a small stream of water is conducted from Mosquito Creek Falls for the relief of the men and use of the drills. The tunnel is for standard gauge track, and is 22 feet high by 16½ feet wide, with an additional excavation of 6 feet 10 inches where timber is needed. The road is of the basaltic formation, and it is said by Superintendent Bennett that 6 feet per day is considered good headway through it. The tunnel is illuminated by electric light, a dynamo being swung from the roof on the line of the center as indicated by the engineers at every 200 feet. The engine which furnishes the electric light is a small portable Erie, and is too small to supply the demand at a much greater distance in the tunnel, and so will be replaced by water power from Mosquito Creek Falls to a wheel with 162 feet head.

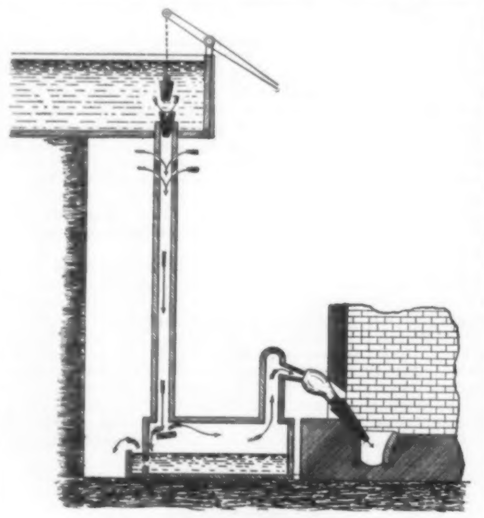
The west end plant is similar, except that the water wheel will be a 50 foot head and the compressors are old style Ingersoll. Besides the narrow-gauge track upon which the muck cars are run from the tunnel to the dump, another track 15 feet wide is laid, upon which is a large elevated platform, which is run up to the breasts; the muck cars are run under this platform, and so the rock from the upper bench is wheeled to and loaded in the cars beneath, while the men below use the same car, which is replaced with an empty as fast as the loaded one is removed. And thus the work is expedited.

At the time of this writing, over 12,000 cubic yards of rock have been taken from this mountain cave and dumped into the cañon beyond the portal, leaving a dark passage toward the west nearly 800 feet long. Thus, for the two years allowed the contractor for putting daylight through the heart of the mountain, will the day shift contend with those on the night turn for the credit of having taken out the greatest quantity of rock, until the driller from the east shall have penetrated the excavation from the west, through which he may caution the workmen on the other side to "look out, he's going to shoot." Meanwhile, the great switchback will have been built over the summit of the Cascade Mountains through the Stampede Pass, and the merchants and officials of St. Paul, by invitation of the Northern Pacific Railroad Co., will doubtless visit Tacoma on the Sound, and stop on the way to see this great work, only now begun.

THE "TROMPE," OR HYDRAULIC BLOWER.

THE manner in which falling water is made use of to keep up a supply of air to the Catalan forge is very simple, very effective, and strikingly ingenious. The blowing machine arrangement is called a "trompe," and is understood to have been invented in Italy in 1640. We have a large cistern, which is supplied with a constant stream of water and connected with another cistern vertically beneath it, as shown, by means of wooden pipes, each measuring some 20 ft. in length. (The length of these vertical pipes is not a constant quantity, but 20 ft. is not an unfair average.) This lower cistern has two openings, one at the top, by which the air gets away through the tuyere into the furnace, and another on one side near the bottom through which the water can get away. The openings of the vertical wooden pipes connecting the two cisterns are, in the upper cistern, partially closed by a kind of wooden funnel, which causes the water to descend in the middle of the pipes instead of clinging to the sides, as might—and as probably would—otherwise be the case. In the upright pipes, and a little below the upper cistern, are cut in an inclined direction several small openings, the inclination being downward. And now let us see how this appliance works. The flow of water into the upright pipes is regulated by plugs, one of which is shown. The water descending is directed into the center of the pipes by the wooden funnel. The descending water produces an "induced current," under the influence of which air is drawn into the pipes through the small inclined apertures, and passes on in considerable quantity along with the water down the pipes. But we do not want air and water to feed the furnace, we want air alone, or as free from water as possible. Immediately below the vertical pipes, and in the lower cistern, we have a board on which the air and water dash themselves, and in so doing separate, the water falling by its greater specific gravity to the bottom of the cistern, and the air by its elasticity and momentum and lightness rising and making its way through the tuyere into the furnace. To prevent the bottom cistern filling with water, an opening is made to enable it to flow away at a certain level, and to prevent any air getting in other than what passes through the vertical pipes. The opening is so arranged that the cistern is trapped, and while the water passes away freely at a certain level, no air can get in, and no air can get out, except through the tuyere.

This explanation, together with the figure, will show with sufficient clearness the manner in which this most economical of blowing engines works, and long experience proves it to work remarkably well. The amount of blast will of course be regulated by the quantity of water which is allowed to flow through the vertical pipes connecting the two cisterns, and the quantity of water is regulated by the position of the wedges, suspended by a chain from a lever immediately above the wooden funnel. When these wedges are dropped into the funnel, the flow of water ceases, and the blast is entirely shut off. When, as in our figures, the wedges are drawn fully up, the flow of water is at a maximum, and the blast is on at the full. Between these two extremes we can have, by varying the position of the wedges, any intermediate flow of water and any intermediate supply of blast. It is something remarkable to have it on the highest authority that no blowing machine produces so constant a pressure of blast as the "trompe." We are told that the mercury, which in any other arrangement has a continuous rising and falling movement, when applied to this machine appears almost as if solid, having no movement. The pressure produced depends very little on the pressure of the water at the higher end of the vertical pipes—that is to say, it depends very little on the fall that the water may have had before reaching the upper cistern, and not even much on the depth of water in the cistern. The pressure of blast produced would seem to depend almost entirely on the height of the vertical pipes, or from the throat of these pipes to the level of the dashboard in the lower cistern. This vertical height will vary, with various forges, from something over 20 ft. to something over 30 ft., and with such heights we should get a pressure in the blast of from 1½ to 2 lb. per square inch. The best results have been obtained with "trompes" producing a blast pressure of 1⅓ lb. per square inch, being equal to about 40 in. of a water gauge, and about 3 in. of a mercury gauge. The one great disadvantage, as will be readily understood, is that with the most perfect arrangements there is an objectionable amount of moisture intermingled with the air; but by regulating the quantity of water to give the best mixture with the air, and a good arrangement of dashboard to assist separation, and determining a correct height at which the air shall pass away to the tuyere, this objection can be reduced to a minimum. There are also certain proportions of the apparatus generally which experience has arrived at, and all assisting this desired separation of air and water. There seems to have been some difficulty in explaining why the "trompe" does such substantial service as a blowing machine, and more than one eminent philosopher has declared his inability to give a satisfactory explanation for the air rushing down. In these days, when so many people are indignant if their capabilities are doubted of assigning good reasons for everything under the sun, it is quite a pleasure and a relief to hear of eminent men admitting that they do not know everything. One eminent philosopher accounted for the blast by the motion which he supposed the falling stream of water communicated to the surrounding air in contact with it. Another, that the water in its descent through the trees increased in velocity, diminished its horizontal section, and caused a vacuum, into which air rushed through the aspirators, and was carried down by the water.



THE "TROMPE," OR HYDRAULIC BLOWER.

The best explanation seems to be given by Professor Goodeve, in his excellent works on mechanics and mechanism. Although dealing with another appliance entirely, namely, the "injector," which also, with its apparently impossible action, puzzled for a time many even of our learned fraternity, the principle applying to that wonderful apparatus would seem to apply equally to the "trompe." The explanation, it may be said, is based upon the principle of "induced currents." Nearly 200 years ago it was shown that when a current of air was sent through a small box, the air within would become rarefied; and if a bottle be partly filled with water, and corked, and a tube passed through the cork and dip with an open end in the water, and the other end be open above the cork to the atmosphere, a current of air blown through a horizontal tube just across the mouth of the vertical one will exhaust the air from the vertical tube, and actually suck the water up. Again, if a small tube be threaded through a plate, with a card in front of it, leaving a small space between the plate and the card, a current of air blown down the tube ought, according to all preconceived opinions, to blow the card away, but instead of doing so the card will be maintained in position, and the air passes out at the annular circumference. The explanation is, that immediately on issuing from the tube the current impinges on the card, and then is reflected on to the plate. This current will diverge in all directions, toward the circumference, and in so doing will sweep out some air from between the plate and the card, actually causing annular spaces to exist round the tube as a center, in which the air pressure is diminished, and the atmospheric pressure without supports the card. The original current of air has "induced" or set up a current in its neighborhood, setting the surrounding air in motion and carrying it away. Siemens' steam jet exhauster, used so effectively for conveying messages through tubes, works on the same principle. A thin annular jet of steam is admitted into the tube, and air is also admitted within and without this annular jet. The steam which is in motion induces a current in the air with which it is in contact, and the two bodies go forward together. In the injector, in the same way, an annular jet of steam is brought into contact all round with water, and we get an "induced current" in the water. The locomotive engine, without which it seems now as if the world could scarcely have an existence, depends for its effectiveness on the steam blast. And this, more or less, is on the same principle. The steam or exhaust, rushing into the smoke box, sets up an induced current in the air with which it comes in contact, and produces an enormous draught in the tubes. And coming back to the "trompe" we have the falling water, which, by means of the funnel, is directed to the center of the vertical pipes, and it passes as a central jet down these pipes, leaving an encircling ring of air in which an "induced current" is set up, and the air is carried forward. As the air within is carried away, air from outside rushes in through the inclined apertures, and, surrounding the central water jet, is carried forward in the same way, and so the operation goes on. And we can now understand the uniformity in the pressure. Provided the quantity of water remains constant, the rush of air cannot vary.

The efficiency of the "trompe" is not high. It may get as high as 0·15, but the average useful effect does not exceed 0·10—that is to say, taking the quantity of water falling and the height through which it falls as representing one horse power, the useful work done in the blast produced would be about 1/10 horse power. But then, although we seem to lose 90 per cent., and do actually not get it, the 10 per cent. gained is actual gain, because it costs us absolutely nothing.

Having dealt at some length with the "trompe," because of the ingenuity of the machine and the beauty of the principle, we want a word about the connection between the lower cistern and the furnace. The tuyere, as shown, by which the blast is brought into the hearth, is somewhat of a truncated cone, and is made by turning a piece of sheet copper into the proper form without soldering its edges. The tuyere rests upon the upper plate of that side of the hearth that we have called the "porges," and incloses the nozzle, through which the air passes. The amount of inclination given to this nozzle is found to materially affect the working of the furnace, and is held as a mystery by the men employed. No doubt there is something in the particular inclination, and also, no doubt, any skillful and attentive workman will discover the correct angle by experience.—*Colliery Guardian.*

ECONOMICAL QUAY WALLS.*

THE following is from a paper by E. Pontzen in the *Nouvelles Annals de la Construction:*

Though the cost of foundations by means of compressed air has been greatly reduced within recent years, there are cases where pile work foundations are still advantageous. As quay walls must be accessible for vessels, it is impossible to strengthen them like ordinary retaining walls by a large batter on the face, by widening out the foundation at the outer toe, or by a mound of rubble in front. Accordingly, as far back as 1837, the plan of pushing forward the foundation by means of sloping piles was adopted at the Glasgow quays. A similar system, with improvements, has been adopted for the new Rouen quay walls. The bed of the Seine, at Rouen, is about 32 ft. below the required quay level, and a layer of silty sand overlies the hard chalk, which is found at about 25 ft. below the river bed. Instead of building a quay wall 33 ft. high on an unstable foundation, or carrying it down to the solid chalk, a wall only 18 ft. high has been built upon piles sloping forward toward the front, and reaching down to the chalk. The thrust of the filling for the quay is kept off from the back of the wall by a mound of rubble stone, and by a layer of rubble stone resting upon a platform supported on piles, carried back far enough for the natural slope of the filling behind, going between the foundation piles under the wall, not to protrude in front of the face of the wall. The wall rests upon four rows of piles, of which the three front rows have a batter of 1 in 8; while the back row, and the four rows supporting the platform behind, are vertical. The lower part of the wall, for a height of 5⅓ ft., is composed of concrete, and is 11 ft. wide, and the upper portion is built of rubble masonry, and has a width of 6½ ft. at the bottom. The wall has a batter of 1 in 8, and is faced with brickwork. The cost of this wall was about £24 per lineal foot. The latest design of quay wall, which is being now built at Rouen for extending the quays, is similar in construction, but has been carried 3¼ ft. lower down, owing to the increasing draught of vessels coming up to Rouen, and in order to allow heavier weights to be placed near the edge of the quay. The concrete is deposited within watertight caissons of beech, 68 ft. long, on the top of the piles. The wall is strengthened by iron tie rods, at intervals of 35 ft., bolted to large blocks of masonry, placed about 66 ft. back from the face of the wall. The last type of wall costs £25 8s. per lineal foot, exclusive of the dredging for placing the toe of the slope low enough for the anticipated deepening of the channel. The author then compares the Rouen quay wall with the New York quay wall along the Hudson River, as executed since 1876. The New York wall is similar in type, being a slight wall of concrete and masonry, backed with rubble, and resting upon long vertical and sloping piles; but the piles are surrounded by a rubble mound which projects in front of the wall, and the wall, though higher than the Rouen wall, is much thinner at the base, and its lower portion has been built with grooved concrete blocks. The top of the wall is about 35 ft. above the bed of the channel, or about the same as at Rouen; but the piles are driven about 20 ft. deeper at New York than at Rouen. The cost of the New York wall, after deducting expenses incurred in the removal of old works, was £39 18s. per lineal foot. It is suggested that the experience of Rouen shows that the rubble surrounding the piles at New York might have been safely dispensed with, that the projection of the rubble mound in front of the face of the wall is prejudicial to vessels, and that the cheaper wall of the Rouen type would have been better for New York than the type adopted.† It is considered, however, that for a long length of quay the concrete block foundation employed at New York would be more economical than the concrete in mass deposited in frames. The above quay walls are less durable than the Antwerp quay wall, founded on firm ground, at a depth of about 60 ft. below quay level, or intermediate between the depth reached by the foundation piles at Rouen and New York. The Antwerp quay wall, founded by aid of compressed air,‡ is strong

* "Proceedings," Institution of Civil Engineers.

† The type referred to was adopted, at New York, in places where the piles could not reach a firm stratum.—"Harbors and Docks," L. F. Vernon-Harcourt, p. 427.

‡ "Harbors and Docks," p. 407 and plates 8 and 14.

enough to resist the thrust of the filling at the back, and also a surcharge of 5 tons per square yard on the quay; but it cost about £93 3s. per lineal foot, or nearly two and a half times the cost of the New York wall, and more than three and a half times the cost of the Rouen wall. The quay wall at Ghent, founded on firm ground met with at a small depth, cost only £31 9s. per lineal foot. The concrete well foundations of the Ninth Dock at Havre* proved an economical system under the special conditions of the site, having cost £34 13s. per lineal foot. Different systems are, accordingly, advisable under varying conditions; but the Rouen type of quay wall has the advantage of enabling quay walls to be extended at ports which, through want of resources, have hitherto possessed inadequate quay accommodation."

THE PHILOSOPHY OF SOARING BIRDS.

By Professor DE VOLSON WOOD.

THE writer was present at the reading and discussion of Mr. Lancaster's paper on "The Soaring of Birds," at the Buffalo meeting of the American Association, an abstract of which is given in the September 4 number of the SUPPLEMENT, No. 557, page 8901. The paper excited considerable interest, not so much on account of the study which Mr. Lancaster appeared to have made, as to the fact that he had made so-called "soaring effigies" of the most simple character, which performed marvelous feats in dead air, and also in air in motion. He also explained his theory, which, taken in connection with the fact that he claimed to have made his theory work with his "effigies," at first made converts to his theory; but, after a little reflection, serious doubts were raised as to the correctness of his observations. They were made five years ago in Florida, with no one to confirm the correctness of his observations; he had made none since; he had no effigies present to show; and when he claimed that he never made them work except at a considerable elevation, some members present offered to find a sufficient elevation near Buffalo, but he did not offer to try the experiment.

On the day following the reading of the paper, a member offered to give to the association fifty dollars if he would produce an effigy, made as he described, that would work as he stated; but Mr. Lancaster made no response. It being difficult to get a full and correct understanding of a paper by hearing it read once, a time was set apart for its further discussion, when it was understood that Mr. Lancaster would produce some models, which would at least illustrate the construction of the "effigies;" but instead thereof, he read that part of his paper which pretended to explain fully the mechanical principles of the soaring birds, and when asked for a model, replied substantially that that was a matter of small consequence, as they were very simple, and the birds themselves offered the best models. One member offered to give $100 if he would produce an effigy that would work as described, but no response. Another member asked if he correctly understood him to say that the effigies, when balanced on his finger, would draw themselves into the breeze, and move against it (see SUPPLEMENT, page 8902), to which he replied that that was the case. Then the member offered $1,000 if he would so make one work; but there was no response. When he stated that he had never made his simplest effigies pass beyond the limits of vision (p. 8902), we assented to its *truth*. When he stated that he could not make his effigy work in a small circle, we believe that to be the *truth;* but when he asserted that the bird gets his power of self-support by soaring horizontally in calm air, we concluded that he knew of principles of mechanics of which the members of the section were ignorant!

The writer handed Mr. Lancaster two sheets of paper, and requested him to show us how to make an "effigy." He took a pine stick and fastened his two pieces of pasteboard, as shown in Fig. 1, with a pendant,

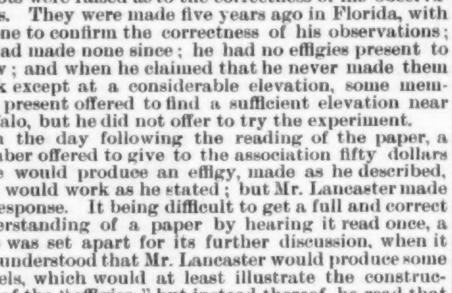


Fig. 1

to keep the device upright. This constituted the simplest kind.

His theory of soaring was as follows: Let B D, Fig. 2, represent the wing of a bird, being rough in the direc-

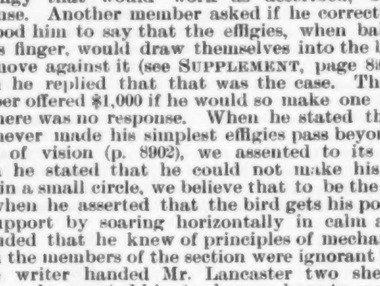


Fig. 2.

tion from D to B, and smooth in the opposite direction; and at the upper edge, B, let there be a ledge on the under side. Let the breeze be horizontal from C toward A; then at A the stream of wind will divide into two parts, one going from A toward B, the other toward D; and the part going toward D will be opposed by little or no friction, while that toward B will be much resisted and finally deflected at B, and both resistance and deflection will produce a force in the direction from A toward B, tending to force the bird upward along the inclined plane. If, now, the slope of the plane be such that gravity will pull the bird downward just as fast as the force along the plane will cause it to rise, the resultant motion will be horizontal and against the wind. This is his theory. We will now subject it to analysis, and see if the conclusion is correct.

Let Q be the mass of air impinging against the surface in a second of time, v its velocity.

Q_1 the quantity flowing toward D, after the stream has impinged against the plane.

Q_2 the quantity flowing toward A.

φ the angle between the normal to the plane and the direction, C A, of the stream. Then,

$$Q_1 = \tfrac{1}{2} Q\,(1 + \sin\varphi),$$
$$Q_2 = \tfrac{1}{2} Q\,(1 - \sin\varphi).$$

Let N be the normal pressure against the plane; then,

$$N = Q\,v \cos\varphi.$$

Draw N S perpendicular to C A, then will A S be the component of the normal, forcing the bird horizontally with the wind, S N, the component acting against gravity. First suppose that the entire energy of Q_1 escapes without friction, and that all of Q_2 is expended against the feathers in the direction A B; then if the horizontal component of $Q_2 v$ exceeds A S, the bird will be pushed against the wind, and the angle of inclination may be so adjusted that the motion will be horizontal. We have,

$$A S = N \cos\varphi = Q\,v \cos^2\varphi,$$
$$Q_2\,v \sin\varphi = \tfrac{1}{2} Q\,v \sin\varphi\,(1 - \sin\varphi);$$

and for equilibrium we have,

$$Q\,v \cos^2\varphi = \tfrac{1}{2} Q\,v \sin\varphi\,(1 - \sin\varphi),$$
$$\text{or,}\quad 1 - \sin^2\varphi = \tfrac{1}{2} \sin\varphi\,(1 - \sin\varphi),$$
$$\text{or,}\quad 1 + \sin\varphi = \tfrac{1}{2} \sin\varphi;$$
$$\therefore\quad \sin\varphi = -2,$$

which is impossible, or in the language of non-Euclidean geometry, the bird must be in hyper-space.

Next, suppose that the stream Q_2 meets with no resistance until it arrives at the ledge, B, and is then completely reversed in direction, as in a cup vein; the pressure exerted would be $2\,Q_2\,v$, and we would have,

$$Q\,v\,(1 - \sin\varphi) \sin\varphi = Q\,v \cos^2\varphi;$$

which reduced gives:

$$0.\ \sin\varphi = 1,$$
$$\therefore\quad \sin\varphi = \infty;$$

or, I suppose, this bird soars in hypo-space.

It is impossible for the plane to float against the breeze, in accordance with Mr. Lancaster's theory.

It also follows, directly, that a weight cannot be maintained statically on this principle, much less move horizontally; but must descend, like the boy's kite, when the string is broken. We venture to assert that if Mr. Lancaster's "effigies" moved in a horizontal plane for hours, they were supported by the buoyancy of the air, on the principle of the balloon, and that they never moved against the breeze unaided. Birds soar, but they do not violate mechanical principles in doing it. Mr. Lancaster is correct in saying that "this whole field is open for experimental investigation."

ANOTHER ELECTRIC LAUNCH.

AN experiment of a more than usually interesting description took place on the River Cart, at Paisley, recently, when a screw launch propelled by electricity was tested. The designer, Mr. James Gibson, Cartha Works, Paisley, claims that it furnishes an easy means of locomotion, and that it has the additional recommendation that in working it will be found to be cheaper than a steam engine giving a similar result in the way of speed. The vessel on which it was tried was of small dimensions, only having a length of about 24 feet and a breadth of beam of 5 feet 3 inches. Secondary cells are used as a motive power, and in this case they were specially brought from London for use. The current is sent through an armature, on the spindle of which is placed square-cut gearing, which reduces the initial velocity from 1,500 revolutions per minute to 240—a speed which sufficed to move the launch at the rate of rather more than seven miles an hour. Another method by which Mr. Gibson has found the power can be satisfactorily communicated is by friction pulleys, which, in order to enable the person to increase or diminish the speed of the vessel as circumstances may dictate, take the form of cones. One of these, measuring 12 inches in length and tapering from 4 inches in diameter down to 2, is placed on the armature spindle, while another of the same length, but having a diameter tapering from 14 to 12 inches, is fitted on the shaft of the propeller. These cones are about three inches apart, and have their surfaces parallel and three inches from each other. The intervening space is filled up with a nest of three smaller cones, which bear on the larger ones, and by moving which to the large or small end of the other cones it is possible to control the speed of the vessel. The invention may be utilized for other purposes than that of the propulsion of vessels. For instance, it may be applied to tramway cars; indeed, says the *Glasgow Herald*, it is in this connection that it is believed it will be found most valuable.

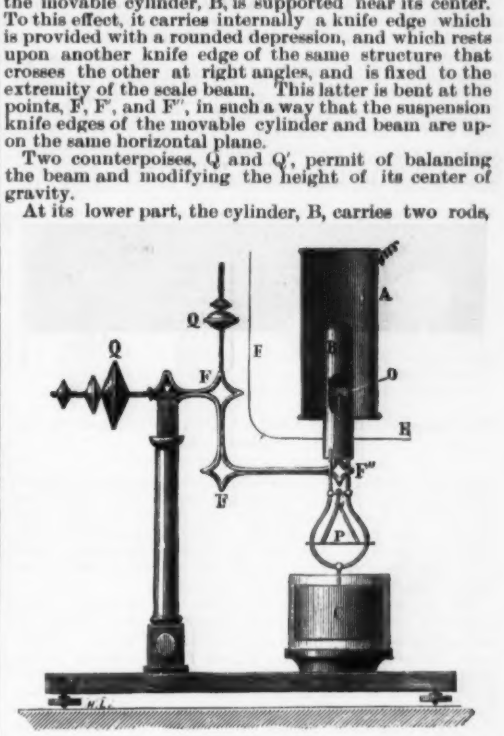
ABSOLUTE ELECTROMETER FOR MEASURING VERY HIGH POTENTIALS.

By E. BICHAT and R. BLONDLOT.

THE electrometer previously described by us permits of accurately measuring potentials as high as 56 electrostatic units C. G. S., which corresponds to an explosive distance of about 5 mm. (⅕ in.). If we exceed such a potential, disturbances occur in the working of the apparatus that are due to the fact that the movable cylinder, being suspended at the extremity of a long rod, is submitted to lateral attractions through which the axes of the two cylinders have no longer the parallelism that the theory of the instrument supposes them to possess. In the new model that we present to-day, the movable cylinder, B, is supported near its center. To this effect, it carries internally a knife edge which is provided with a rounded depression, and which rests upon another knife edge of the same structure that crosses the other at right angles, and is fixed to the extremity of the scale beam. This latter is bent at the points, F, F', and F'', in such a way that the suspension knife edges of the movable cylinder and beam are upon the same horizontal plane.

Two counterpoises, Q and Q', permit of balancing the beam and modifying the height of its center of gravity.

At its lower part, the cylinder, B, carries two rods,



ABSOLUTE ELECTROMETER FOR MEASURING VERY HIGH POTENTIALS.

between which passes the beam, and which afterward unite to support a cylinder, C, formed of paper stretched over a metallic skeleton. This cylinder, C, serves to deaden the oscillations of the balance. To this effect, it is placed in a cylindrical vessel of a slightly larger diameter, which is provided with a cover that contains an aperture for the passage of the suspension rod.

A pan, P, suspended from the cylinder, B, receives the weights designed to measure the attraction exerted by the cylinder, A, upon the cylinder, B.

A curved screen, EEE, containing an aperture, allows the movable cylinder to pass.

The advantages of the new arrangement are the following: As the suspension point of the movable cylinder is situated in the center, it results that the movements of the lateral attractions are, on the one hand, very feeble, and, on the other, are partially compensated for. The disturbance alluded to above is thus nearly annulled. Besides, as the deadener, C, is placed very far down, and is quite heavy, it tends to keep the movable cylinder vertical.

We thus obtain an absolute stability, and the measurements may be extended up to potentials that correspond to explosive distances of 2·5 cm. (one inch).

The formula that expresses the absolute value of the square of the potential as a function of the weight $p\varpi$ necessary to balance the attraction of the two cylinders is, as for the first model,

$$V^2 = 4 p\, g\, L \frac{R}{r}$$

where R and r designate the radii of the two cylinders and g the acceleration of the weight.

A very perfect model of this instrument has been constructed by Mr. D. Gaiffe, of Nancy, who has been able to associate lightness with great strength. We have applied it to the measurement of potentials corresponding to explosive distances varying from one to 22 mm. (⅜ to 8½ inches), between two balls 1 cm. (⅜ in.) in diameter. The results are given in the following table. Opposite our figures we give the corresponding ones obtained by Mr. Baille by means of a Thomson guard ring electrometer, for explosive distances between 1 and 10 mm. (⅜ and 4 in.).

Explosive distances.	Potentials in electrostatic units. Bichat and Blondlot. cm.	Baille. cm.
0·1	16·1	15·25
0·2	27·5	26·82
0·3	38·2	37·32
0·4	47·7	47·62
0·5	56·3	54·96
0·6	64·8	65·23
0·7	71·6	72·28
0·8	77·0	77·61
0·9	81·6	80·13
1·0	84·7	83·05
1·1	88·7	"
1·2	91·3	"
1·3	93·8	"
1·4	95·8	"
1·5	97·8	"
1·6	99·2	"
1·7	100·8	"
1·8	101·8	"
1·9	103·2	"
2·0	104·5	"
2·1	105·4	"
2·2	106·4	"

For the part common to Mr. Baille's and our own experiments, the figures show all the concordance that could be expected from measurements of this nature, taking into consideration the alteration of the surface of the balls of the exciter due to the spark itself.—*Comptes Rendus.*

* "Minutes of Proceedings," Inst. C. E., vol. lxxxi., p. 361.

[Concluded from SUPPLEMENT, No. 562, page 8980.]

[NATURE.]

CAPILLARY ATTRACTION.

By WILLIAM THOMSON.

IN these other diagrams, however (Figs. 13 to 28), we have certain portions of the curves taken to represent real capillary surfaces shown in section. In Fig. 13, a solid sphere is shown in four different positions in contact with a mercury surface; and again, in Fig. 14, we have a section of the form assumed by mercury resting in a circular V-groove. Figs. 15 to 28 show water-surfaces under different conditions as to capillarity; the

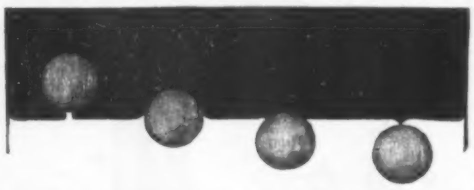


FIG. 13.—Mercury in Contact with Solid Spheres (say of glass).

scale of the drawings for each set of figures is shown by a line, the length of which represents one centimeter; the dotted horizontal lines indicate the positions of the free water level. The drawings are sufficiently explicit to require no further reference here, save the remark that *water* is represented by the lighter shading and *solid* by the darker.

We have been thinking of our pieces of rigidified water as becoming suddenly liquefied, and conceiving them inclosed within ideal contractile films. I have here an arrangement by which I can exhibit on an enlarged scale a pendent drop, inclosed, not in an *ideal* film, but in a *real* film of thin sheet India rubber. The apparatus which you see here suspended from the roof is a stout metal ring of 60 centimeters diameter, with its aperture closed by a sheet of India

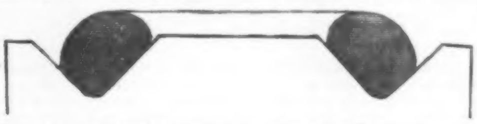
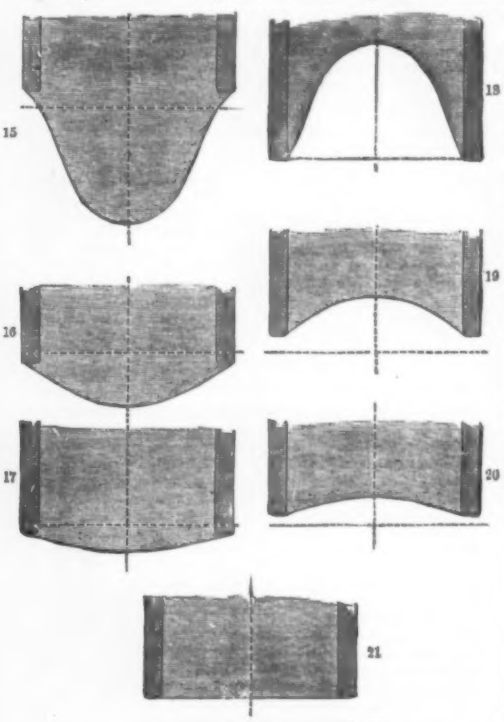


FIG. 14.—Sectional View of Circular V-groove containing Mercury.

rubber tied to it all round, stretched uniformly in all directions, and as tightly as could be done without special apparatus for stretching it and binding it to the ring when stretched.

I now pour in water, and we find the flexible bottom assuming very much the same shape as the drop which you saw hanging from my finger after it had been dipped into and removed from the vessel of water (see Fig. 16). I continue to pour in more water, and the form changes gradually and slowly, preserving meanwhile the general form of a drop such as is shown in Fig. 15, until, when a certain quantity of water has been poured in, a sudden change takes place. The sudden change corresponds to the breaking away of a real drop of water from, for example, the mouth of a tea-urn, when the stopcock is so nearly closed that a



FIGS. 15-21.—Water in Glass Tubes, the Internal Diameter of which may be found from Fig. 22, which represents a Length of One Centimeter.

very slow dropping takes place. The drop in the India rubber bag, however, does not fall away, because the tension of the India rubber increases enormously when the India rubber is stretched. The tension of the real film at the surface of a drop of water remains constant, however much the surface is stretched; and therefore the drop breaks away instantly when enough of water has been supplied from above to feed the drop to the greatest volume that can hang from the particular size of tube which is used.

I now put this siphon into action, gradually drawing off some of the water, and we find the drop gradually diminishes, until a sudden change occurs, and it assumes the form we observed (Fig. 16) when I first poured in the water. I instantly stop the action of the siphon, and we now find that the great drop has two possible forms of stable equilibrium, with an unstable form intermediate between them.

Here is an experimental proof of this statement. With the drop in its higher stable form I cause it to vibrate so as alternately to decrease and increase the axial length, and you see that when the vibrations are such as to cause the increase of length to reach a certain limit, there is a sudden change to the lower stable form, and we may now leave the mass performing small vibrations about that lower form. I now increase these small vibrations, and we see that whenever, in one of the upward (increasing) vibrations, the contraction of axial length reaches the limit already referred to, there is again a sudden change, which I promote by gently lifting with my hands, and the mass assumes the higher stable form, and we have it again performing small vibrations about this form.

The two positions of stable equilibrium, and the one of unstable intermediate between them, is a curious peculiarity of the hydrostatic problem presented by the water supported by India rubber in the manner of the experiment.

I have here a simple arrangement of apparatus (Figs. 29 and 30) by which, with proper optical aids, such as a cathetometer and a microscope, we can make the necessary measurements on real drops of water or other liquid, for the purpose of determining the values of the capillary constants. For stability, the drop hanging from the open tube should be just less than a hemisphere, but for convenience it is shown, as in the enlarged drawing of the nozzle (Fig. 30), exactly hemispherical. By means of the siphon the difference of levels, h, between the free level surface of the water in the vessel to which the nozzle is attached and the lowest point in the drop hanging from the nozzle may be varied, and corresponding measurements taken of h and of r, the radius of curvature of the drop at its lowest point. This measurement of the curvature of the drop is easily made, with somewhat close accuracy, by known microscopic methods. The surface-tension, T, of the liquid is calculated from the radius, r, and the observed difference of levels, h, as follows:

$$\frac{2T}{r} = h;$$

for example, if the liquid taken be water, with a free-surface tension of 75 milligrammes per centimeter, and $r = 0{\cdot}05$ cm., h is equal to 3 centimeters.

Many experiments may be devised to illustrate the effect of surface-tension when two liquids, of which the surface-tensions are widely different, are brought into contact with each other. Thus we may place on the surface of a thin layer of water, wetting uniformly the surface of a glass plate or tray, a drop of alcohol or ether, and so cause the surface-tension of the liquid layer to become smaller in the region covered by the alcohol or ether. On the other hand, from a surface-layer of alcohol largely diluted with water, we may arrange to withdraw part of the alcohol at one particular place by promoting its rapid evaporation, and thereby increase the surface-tension of the liquid layer in that region by diminishing the percentage of alcohol which it contains.

In this shallow tray, the bottom of which is of ground glass resting on white paper, so as to make the phenomena to be exhibited more easily visible, there is a thin layer of water colored deep blue with aniline; now, when I place on the water-surface a small quantity of alcohol from this fine pipette, observe the effect of bringing the alcohol-surface, with a surface-tension of only 25·5 dynes per lineal centimeter, into contact with the water-surface, which has a tension of 75 dynes per lineal centimeter. See how the water pulls back, as it were, all round the alcohol, forming a circular ridge surrounding a hollow, or small crater, which gradually widens and deepens until the glass plate is actually laid bare in the center, and the liquid is heaped up in a circular ridge around it. Similarly, when I paint with a brush a streak of alcohol across the tray, we find the water drawing back on each side from the portion of the tray touched with the brush. Now, when I incline the glass tray, it is most interesting to observe how the colored water, with its slight admixture of alcohol, flows down the incline, first in isolated drops, afterward joining together into narrow continuous streams.

These and other well-known phenomena, including that interesting one, "tears of strong wine," were described and explained in a paper "On Certain Curious Motions Observable on the Surfaces of Wine and Other Alcoholic Liquors," by my brother, Prof. James Thomson, read before Section A of the British Association at the Glasgow meeting of 1855.

I find that a solution containing about 25 per cent. of alcohol shows the "tears" readily and well, but that they cannot at all be produced if the percentage of alcohol is considerably smaller or considerably greater than 25. In two of those bottles the colored solution contains respectively 1 per cent. and 90 per cent. of alcohol, and in them you see it is impossible

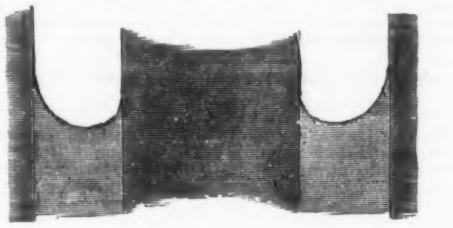


FIG. 23.—Water resting in the Space between a Solid Cylinder and a Concentric Hollow Cylinder.

to produce the "tears;" but when I take this third bottle, in which the colored liquid contains 25 per cent. of alcohol, and operate upon it, you see—there—the "tears" begin to form at once. I first incline and rotate the bottle so as to wet its inner surface with the liquid, and then, leaving it quite still, I remove the stopper, and withdraw, by means of this paper tube, the mixture of air and alcoholic vapor from the bottle, and allow fresh air to take its place. In this way I promote the evaporation of alcohol from all liquid surfaces within the bottle; and where the liquid is in the form of a thin film, it very speedily loses a great part of its alcohol. Hence the surface-tension of the thin film of liquid on the interior wall of the bottle comes to have a greater and greater value than the surface-tension of the mass of liquid in the bottom; and where these two liquid surfaces, having different surface-tensions, come together, we have the phenomena of "tears." There, as I hasten the evaporation, you see the horizontal ring rising up the side of the bottle, and afterward collecting into drops, which slip down the side, and give a fringe-like appearance to the space through which the rising ring has passed.

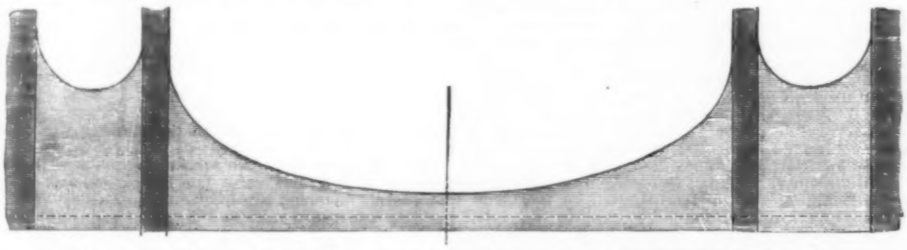


FIG. 24.—Water resting in Two Co-axal Cylinders. (Scale is represented by Fig. 28.)

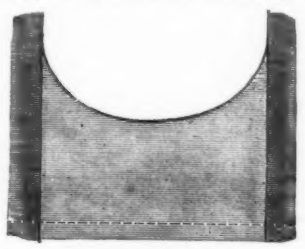
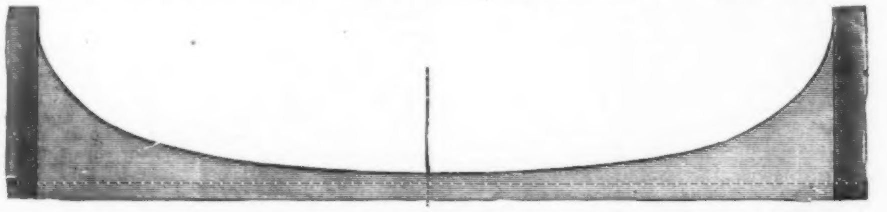


FIG. 25.

These phenomena may also be observed by using, instead of alcohol, ether, which has a surface-tension equal to about three-fourths of that of alcohol. In using ether, however, this very curious effect may be seen:* I dip the brush into the ether, and hold it near to, but not touching, the water-surface. Now I see a hollow formed, which becomes more or less deep, according as the brush is nearer to or farther from the normal water surface, and it follows the brush about as I move it so.

Here is an experiment showing the effect of heat on surface-tension. Over a portion of this tin plate there is a thin layer of resin. I lay the tin plate on this hot copper cylinder, and we at once see the fluid resin drawing back from the portion of the tin plate directly over the end of the heated copper cylinder, and leaving a circular space on the surface of the tin plate almost clear of resin, showing how very much the surface-tension of hot resin is less than that of cold resin.

Note of January 30, 1886.—The equations (8) and (9) on p. 59 of Clerk-Maxwell's article on "Capillary At-



FIGS. 25 AND 26.—Water resting in Hollow Cylinders (Tubes). (Scale is represented by Fig. 28.)

* See Clerk-Maxwell's article (p. 65) on "Capillary Attraction" ("Encyclopædia Britannica," 9th edition).

traction," in the ninth edition of the "Encyclopædia Britannica," do not contain terms depending on the mutual action between the two liquids; and the concluding expression (10), and the last small print paragraph of the page, are wholly vitiated by this omission. The paragraph immediately following equation (10) is as follows:

"If this quantity is positive, the surface of contact will tend to contract, and the liquids will remain distinct. If, however, it were negative, the displacement of the liquids which tends to enlarge the surface of contact would be aided by the molecular forces, so that

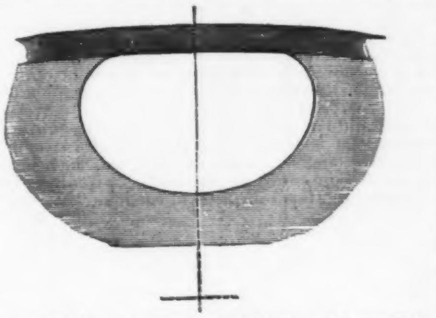


FIG. 27.—Section of the Air-bubble in a Level Tube filled with Water, and bent so that its Axis is part of a Circle of Large Radius. (Scale is represented in Fig. 28.)

the liquids, if not kept separate by gravity, would become thoroughly mixed. No instance, however, of a phenomenon of this kind has been discovered, for those liquids which mix of themselves do so by the process of diffusion, which is a molecular motion, and not by the spontaneous puckering and replication of the boundary surface, as would be the case if T were negative."

It seems to me that this view is not correct, but that, on the contrary, there is this "puckering" as the *very*

FIG. 28.—Represents a Length of One Centimeter for Figs. 24 to 27.

beginning of diffusion. What I have given in the lecture as reported in the text above seems to me the right view of the case as regards diffusion in relation to interfacial tension.

It may also be remarked that Clerk-Maxwell, in the large print paragraph of p. 59, preceding equation (1), and in his application of the term potential energy to E in the small print, designated by *energy* what is in reality exhaustion of energy, or negative energy; and

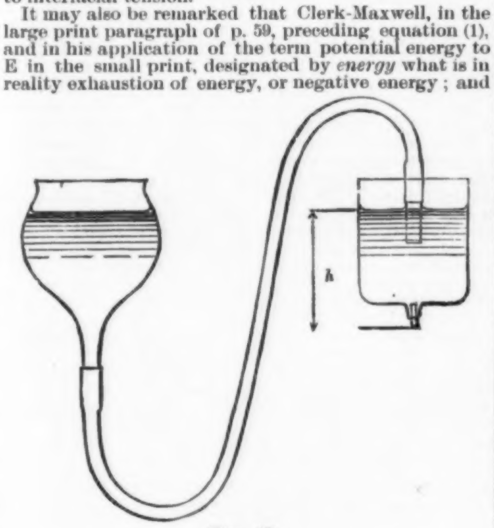


FIG. 29.

The same inadvertence renders the small print paragraph on p. 60 very obscure. The curious and interesting statement at the top of the second column of p. 63, regarding a drop of carbon disulphide in contact with a drop of water in a capillary tube, would constitute a perpetual motion if it were true for a tube not first wetted with water through part of its bore: ". . . If a drop of water and a drop of bisulphide of carbon be placed in contact in a horizontal capillary tube,

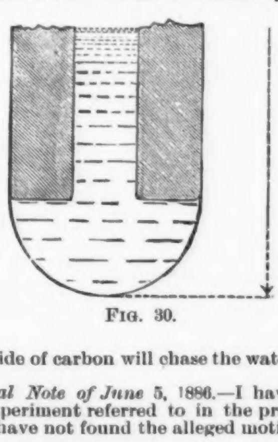


FIG. 30.

the bisulphide of carbon will chase the water along the tube."

Additional Note of June 5, 1886.—I have carefully tried the experiment referred to in the preceding sentence, and have not found the alleged motion.

PRESIDENT ADAMS of Cornell University says in the fertility of the soil nature seems to be a beneficent and all-bountiful mother. But it is the all-pervasive law of nature that the mother that feeds us requires in turn to be fed.

SOAP BUBBLES.

THE Friday evening discourse during the meeting of the British Association was delivered by Prof. Rucker, M.A., F.R.S., who took for his subject "Soap Bubbles." The lecturer commenced by stating that the curious and beautiful phenomena displayed by soap bubbles had, at all events for many centuries, attracted considerable attention. In the Museum of the Louvre in Paris there was an Etruscan vase on which was depicted a group of children blowing bubbles. We thus learned not only that the sport was of considerable antiquity, but that the graceful attitudes of the children engaged in it suggested a fitting theme for artistic treatment alike to the Etruscan potter and to the Royal Academician of to-day. It would be strange if natural phenomena which had attracted such attention should have been passed over by those whose special duty it was to attempt to interpret nature, and as a matter of fact it had not been so. Scientific men had studied bubbles carefully, but in spite of this there were many points connected with them which were too imperfectly understood. The lecturer, therefore, made no apology for the apparent triviality of his subject, and made no attempt to cover the wide ground which the title indicated. He asked the attention of his audience while he dwelt for the most part upon one, and one only, of the most interesting, but least studied, peculiarities of soap films.

He need hardly remind them that the explanations of the colors of soap films was one of the triumphs of the theory of light. That explanation had now become one of the commonplaces of science, and applied not only to soap films, but to other phenomena, such as those to be exhibited by Professor Roberts-Austen next evening. He wished, however, to impress upon his audience at the beginning that the colors of films not only enabled us to measure their thickness, but within certain limits afforded us a very accurate measure of their thickness. The thickest soap films were so thin that it was convenient to employ a very small unit of length in measuring them. He therefore chose the millionth of a millimeter, or the twenty-five millionth part of an inch, and said he would express the magnitudes with which he would have to deal in terms of that unit. The thick soap film displayed no colors, and it might be said that the first tints were seen when its thickness was, in round numbers, two thousand millionths of a millimeter. The colors succeeded one another in regular order, but at last the film became black. According to Newton, the point at which this took place was when the thickness of the film was thirty-six millionths of a millimeter; and thereafter, however thin the film might become, no further change in color was exhibited.

A knowledge of the colors enabled the skilled observer to study the thickness of the film to within about 1 per cent., but this power failed when the film was either too thick to display any color or so thin that it displayed nothing but the black. In this case, however, as in many others, information became specially difficult to obtain just at the point when it was specially interesting. It was by the study of extremely thin films that we might expect to learn most with regard to the molecular composition of liquids. A liquid was held together by means of attractive forces in play between the particles of which it was composed. A particle within a liquid was surrounded by others upon all sides, and was therefore attracted upward as well as downward, to the right as well as to the left. But the particle in the surface had neighbors on one side only, and thus the attraction exerted upon it was on the whole downward. It followed from this that, since particles in the surface and in the interior were acted upon differently by molecular forces, they would probably be differently arranged among themselves; and since the properties of a body depended not only on its chemical composition, but also on the arrangement of its particles, we should expect that the surface of the liquid would display phenomena of which the interior showed no trace. As a matter of fact it was so, and the liquid must therefore be regarded as consisting of two parts—the interior, throughout which the properties are uniform, and a very thin surface layer, in which the properties are somewhat modified.

The soap bubble, therefore, if tolerably thick, must be regarded as composed of an interior and two surface layers. If it became so thin that the interior position drained away and the two surface layers met, we might then expect that it would display some novel phenomena from which instructive information as to the nature of molecular forces might be obtained. Now, there was in connection with a film which displayed the black one phenomenon which seemed to show that a limit something like this had been reached. In general the colors of a film faded gradually the one into the other, proving that the thickness changed gradually from point to point. The edge of the black, however, was nearly always a sharp line, and the color which came next before it was often such as to prove that there was a sudden and very great change of thickness between the black portion of the film and that with which it appeared to be in contact. In some cases the black was at least 55 times thinner than the film which touched it. Bearing these facts in mind, the lecturer and Prof. Ethos Reinold some time ago undertook the study of the black portions of soap films, and the first question which they set themselves to solve was to determine, if possible, what this thickness might be.

In order to measure the thickness of the black film, they began by studying the resistance which liquid films offered to the electric current. If the ordinary laws held good in the case of such films, it was to be expected that the resistance would increase in the same proportion as the thickness diminished, so that if the thickness were halved the resistance would be doubled, and so on. There were many difficulties in proving that this law held good; but the experimenters succeeded in showing that it certainly did so as long as the thickness of the film was greater than about 400 millionths of a millimeter. Below that their experiments did not enable them to speak with certainty. It was very evident that if the law held good for greater degrees of tenuity, it would enable them to measure the thickness of a black film by measuring its electrical resistance; for if that resistance were a hundred times greater than that of a film so thick that its color enabled them to measure its thickness, they would thus know that the thickness of the black film was a hundred times less. Pursuing this method, two sets of experiments were made, which gave accordant results. The mean of the first proved that the black had a thickness of 11·9 millionths of a millimeter; the mean of the second that its thickness was 11·7 millionths of a millimeter.

As it was very important to make certain that the assumption was really true that the law on which this calculation was based held good for films, the experimenters devised another and an independent way of measuring the thickness of a film by means of optical observation. The mean result was in complete accord with that previously obtained, being 11·5 millionths of a millimeter. It followed, then, that any theory which was to satisfactorily account for the properties of a surface of a liquid must explain, first, the sudden change in thickness at the edge of the black; secondly, the constant thickness of the black itself; and, thirdly, the fact that the thickness of the film in contact with the black might on different occasions be very different. To explain this the lecturer discussed the properties of the surfaces of liquids. He showed in the first place that the viscosity of the surface was often very different from that of the interior, a fact which was illustrated by experiment. He then showed by other experiments the well known fact that the surface of a liquid is in a state of tension—that is, like a blown out bladder, which tends to contract. It had generally been supposed that if a film became so thin that all the interior liquid drained away, and the two surface layers began to intermingle, the surface tension would diminish; and many experiments had been made to obtain indications of this expected decrease in the surface tension.

The result of these observations had been to prove that no such change could be detected; but as all such experiments had been made on comparatively thick films, the lecturer and Prof. Reinold had recently extended them to the case of films thin enough to show the black. In doing this they had the authority of Maxwell to support the view that much might be learned by such methods, as he said in his article on "Capillarity," in the "Encyclopædia Britannica," that measurements of the tension of the film, when drawn out to different degrees of thickness, might possibly lead to an estimate of the range of the molecular forces. The lecturer described the difficulties with which the investigation was beset, but stated that the final result arrived at was that if the black part of the film formed steadily, spreading quietly over the remainder of the surface, no change of surface tension could be detected, and calculation showed that their experiments would have enabled them with certainty to detect a change of a half per cent. Sometimes, however, the black part of the film formed with great rapidity; and though it was impossible to secure that this state of things should take place at a given time, yet on the few occasions when the experimenters were able to make observations they found that the formation of the black in this way was accompanied by a change of surface tension.

They had further proved a very curious fact—that if an electric current were passed through a soap film, it would apparently carry the liquid with it, so that, if it was sent up the film, it thickened it, and if sent down the film, thinned it. By sending the current up a film which was partly black and partly colored, they found that they could obliterate the sharp edge of the black; but that when the current was removed, the sharp edge, in the course of a few seconds, was formed again. The general result of these experiments was to show that when the film was a little thicker than the black there was an unstable thickness which could not permanently last, and that if the film were by means of the current forced to assume that thickness, it immediately, on the removal of the current, became thicker and thinner, and the thick and thin parts apparently were in direct contact. The forces which produced this change were certainly less than 2 per cent. of the surface tension, probably less than a half per cent.; and the viscosity of the film permitted the effect of the complete separation of the thick and thin parts to take place in a few seconds.

It remained, then, to explain these facts. Prof. Reinold and the lecturer came to the conclusion that they could best be explained by supposing that when the two surface layers of the film began to intermingle the first effect was—as had generally been supposed—a decrease in the surface tension, but that this decrease was in turn replaced by an increase, so that there was a minimum of surface tension for some particular thickness rather greater than that which displayed the black. In this view they were confirmed by Sir William Thomson, who they found had, unknown to them, expressed a similar opinion in a lecture given early in the present year. It remained, then, to explain further why this *minimum* of surface tension existed, and here the lecturer thought that the true key was to be found in a calculation of Maxwell's given in the article of which he had spoken. Maxwell showed that the surface tension would increase or decrease according to the relation of the thickness of the film to the distance at which the molecules repelled or attracted one another. If they attracted one another, the surface tension would fall off as the film became thinner; if they repelled one another, the surface tension would increase. Hence in the sharp edge of the black the lecturer believed that we had experimental evidence, first, of a *minimum* of surface tension, and, second, of an alteration in the nature of the force in play between the molecules, which had been often assumed in physical investigations, but of which any direct proof was, he believed, wanting.

The lecturer concluded by pointing out to the audience that the result to which his investigations had led seemed to afford hope that the state of tenuity might throw further light upon obscure and difficult questions connected with the nature of the forces in play between the particles of which liquids are composed.

COLORS OF METALS AND ALLOYS.

THE Saturday evening or popular lecture during the meeting of the British Association was delivered by Prof. W. C. Roberts-Austen in the Town Hall, a large number of the working classes attending. Prof. Roberts-Austen stated that under the title of the lecture he intended to include the consideration of the principal facts connected with the colors of metals and alloys, whether natural to them or produced by metallurgical

art, as well as a brief examination of the kind of influence which the colors of metals appear to have exerted on the history of chemical science. With reference to the recognition of colors of metals by the ancients, he referred to the view expressed some years ago by Mr. Gladstone, that "the starting point is absolute blindness to color in the primitive man," and he urged that, if this be true, it is strange that in the metal work or fabrics of savage nations the arrangement of such colors as they can obtain should be so thoroughly "understood," and the colors themselves so discriminatingly employed. Allusion was then made to the ancient belief that the seven metals known to the early chemists were specially connected, as regards color, with the seven principal planets; to the persistence with which this belief survived; and to the fact that Sir Isaac Newton did not escape the charge of leaning toward mysticism when he stated that seven colors resulted from the decomposition of light by the prism. In relation to the influence of the color of metals on the history of science, it was pointed out that from the 3d to the 17th century the color of gold appeared to haunt men, and induced the alchemists to make the strangest sacrifices, even of life itself, in the attempt to produce it. The alchemists were sustained by the knowledge that the color of metals could be destroyed by small traces of impurity, and an appeal was made to the argument of even the "skeptical chemist," Robert Boyle, in the 17th century, that transmutation of base to precious metals is possible, because he destroyed the color of gold, and believed that he had degraded gold to a base metal by the addition of a small quantity of a substance "given him by a stranger;" "it being," as Boyle said, "no small thing to have removed the bounds which nature has industriously set to the alteration of things." In illustration of the apparent degradation of gold by the presence of a small quantity of certain other metals, Prof. Roberts-Austen melted 200 sovereigns, added a tiny shot of lead, and proved that the bar into which the metal was cast was very brittle, and entirely different in color from the original gold. The dependence of the colors of metals on their physical state of aggregation was then illustrated by some beautiful experiments with leaf-gold and with Faraday's finely divided gold of bright ruby color. The lecturer then passed to the effect of color produced by alloying metals by melting them together. He incidentally said that he had many inducements to speak about brass—in particular he would have liked to dwell upon the beauty of such work as that of the great craftsman (William Austen) who, in 1460, made the magnificent monument in brass to Richard Beauchamp, Earl of Warwick; and he was glad to remember that the first patent for the manufacture of brass in England had been granted to W. Humphrie, an assay master of the mint, and a predecessor in the office he was privileged to hold—but he did not intend to say much in Birmingham of the colored alloy of zinc and copper which was its staple industry. His object was to claim the attention of the metal-workers of Birmingham to the colored alloys of copper with which they were less familiar, and he referred at length to the alloys which had been used for centuries by Japanese art metal-workers, the images of beautiful specimens of whose handicraft were projected on a screen. Special reference was made to a large plaque of copper inlaid with foliage, which in color suggested the glories of a Canadian autumn, and it was stated that the addition of small quantities of gold, antimony, and cobalt to metallic copper enabled the Japanese to secure each beautiful shade of color of purple, golden browns, and reds, for which their art metal work is so remarkable. In illustration of the effect of various "pickling" solutions on copper, Prof. Roberts-Austen had himself prepared a trophy 7 ft. high of richly colored leaves. Attention was then directed to the singular banded alloy known as moku-me, the manufacture of which, now almost abandoned by the Japanese, Prof. Roberts-Austen is anxious to see introduced into this country; and he projected on the screen the image of a dagger-hilt of old Japanese native workmanship, in which, as a *tour de force*, the artist had reproduced the purple and brown markings of a "scarlet-runner" bean. A brief reference was made to the fact that the electro-metallurgist has at command, in the power of being able to deposit colored alloys, an equivalent of the varied palette of the decorator; and beautiful specimens of colored alloys, deposited by Messrs. Elkington's well-known firm, were exhibited. It was incidentally stated that one firm deposited annually six tons of silver in thin films, which, if continuous, would, it had been calculated, cover an area of 140 acres. Prof. Roberts-Austen then showed experimentally, by projection on the screen, the formation of colored films by heating lead in air, and he claimed that the formation of a colored calx of lead by heating the metal in air had been more frequently appealed to in support of various sets of views than any other fact in the history of science, from the time of Geber in the 8th century to that of Priestley in the 18th. This beautiful experiment was of special interest to Birmingham, because, performed in a rougher way, it had directly led Priestley to the discovery of oxygen, and had removed his doubts as to the aerial source of the oxygen he obtained from other substances. Prof. Roberts-Austen concluded with a sentence from Mr. Ruskin's "Modern Painters," as to the right enjoyment of color, and with a plea for the more careful study and extended adoption of colored metals and alloys in objects intended for daily use, and for the restricted employment of gold and silver to the legitimate purpose of enriching metallic ornament.

NITRATES AND NITRITES IN WATERS AND ARTIFICIAL SOLUTIONS.

The current number of the *Journal of the Chemical Society* comprises a lengthy paper giving the results of a series of experiments on the above subject, extending over more than three years, by Dr. Munro, of the College of Agriculture, Downton, Salisbury. The author considers in succession the nitrification of nitrogenous compounds other than ammonium salts, the nitrification of ammonium salts in artificial solutions in well and river waters, and the denitrification and the influence of organic matter on nitrification. The nitrogenous compounds other than ammonium salts that were experimented upon comprised ethylamine, potassium thiocyanate, ammonium thiocyanate, thiocarbamide, urea, gelatine, and urine. The ammonium salts consisted of the chloride and the oxalate. In 1884 Mr. Warrington published the results of some researches on this subject in the *Journal of the Chemical Society*, and it is known that he is continuing them. Dr. Munro's results afford some interesting information as to the powerful nature of soils in reducing the ammonium applied to them in the form of salts of that substance as manures; and, if further substantiated, they will also considerably modify accepted views on the subject of the presence of nitrates in potable waters, the phenomena following the contamination of water by sewage, etc.

LIQUID CARBONIC ACID.

We have mentioned on various occasions different applications of liquefied carbonic acid to industrial purposes, which seem likely to extend as the manufacture of the acid is improved, and facilities of obtaining it in

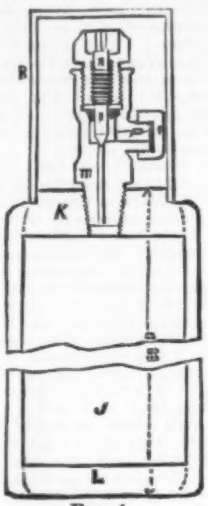


Fig. 1.

a convenient form are increased. A company, which was formed some time ago at Berlin for working Dr. Raydt's inventions for producing and liquefying carbonic acid, has obtained very encouraging results. It supplies the liquid acid in wrought iron bottles, containing about 10 liters or 16 lb., which thus places at the disposal of the consumer about 160 cubic feet of gas at atmospheric pressure. This presents every facility for users, as the gas in its liquid state occupies only a very

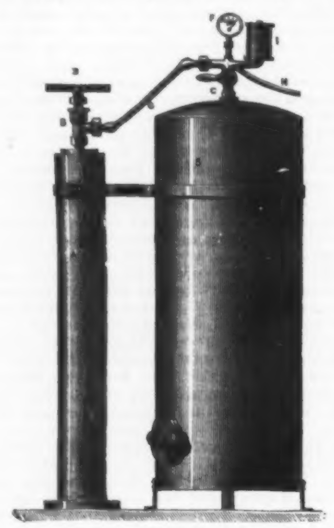


Fig. 2.

INDUSTRIAL APPLICATION OF LIQUID CARBONIC ACID.

small space, and consequently large quantities can be concentrated and transported in vessels of small dimensions. A section of the bottles used is shown by Fig. 1. They consist of a welded wrought iron tube of 5½ in. outside diameter, into which the thick ends, L and K, are welded, the ends being made taper toward the outside, and the tube bent over as indicated by the dotted lines. A gun metal valve, *m*, is screwed into the upper end, the opening being closed by the screwed steel

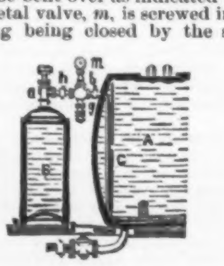


Fig. 3.

spindle, *n*. The branch, *p*, is closed by a cap, *o*, and the valve covered by a protecting capsule, R, during carriage or storage. Before use the bottles are tested to a pressure of 250 atmospheres, and may therefore be considered safe against explosion, as the pressure of carbonic acid at the freezing point of water, or 0° C., is 36 atmospheres, and at 30° C., 74 atmospheres. The pressure also increases at a regular rate without sudden jumps, which might injure the solidity of the apparatus, and the German railway companies have authorized the carriage of these bottles by all trains.

One of the principal applications the liquid has obtained is that of drawing beer, which has already become largely extended in Germany. In France also the results obtained have received the approbation of the Hygienic Council, and the use of the acid for this purpose was sanctioned by the legal authorities of Paris about a year ago. Beer has hitherto been drawn from the barrels in the cellar either by pumps or forced up by compressed air. Although these methods answer fairly well with the English ales, they do not suit the Continental lager beer, as contact with the air rapidly deprives it of the carbonic acid it contains and makes it flat, and otherwise deteriorates its quality, while a half emptied barrel of English ale may stand for a considerable time without becoming flat; lager beer under the same condition becomes unpalatable in a day or two. It rapidly turns sour and leaves in the barrels and pipes deposits, causing fermentation and spoiling the beverage. By the use of carbonic acid these drawbacks are entirely obviated, the beer retaining its sharpness and flavor, and poor qualities become improved by the absorption of carbonic acid.

SULPHURIC ACID IN REFINED PETROLEUM AND DISTILLATE.

Refined petroleum invariably contains small amounts of sulphuric acid derived from the acid employed in its manufacture. Numerous experiments and determinations have shown that this cannot be removed by the usual washing with water and alkali, and that the acid is chemically combined with the petroleum. The application of many extra water and alkali washes reduces the amount of acid only to a very limited extent.

The cheap grades of oil contain quite a large per cent. of hydrocarbon, obtained from the destructive distillation of the heavy portions of the crude petroleum; or, in other words, they contain olefines and hydrocarbons of series other than the paraffine series. These oils retain larger amounts of acid than water white oil; and it may be stated that the amount of acid in refined oil is indicative of the amount of the products of destructive distillation in it.

The following table shows the amount of sulphuric anhydride (SO_3) in grains per English gallon, in three grades of oil:

Water white. 150 deg. fire test.	New York State. 100 deg. flash.	Able oil, for export.
		21·0 grs. per gal.
7·4 grs. per gal.	9·5 grs. per gal.	21·4 " "
6·6 " "	9·9 " "	19·5 " "
6·9 " "	13·2 " "	18·5 " "
7·0 " "	14·2 " "	21·7 " "

The above are selected from a large number of determinations, and represent the variation which will be found in those oils. Difference in gravity does not account for the different amounts of acid; for, while water white is lighter than the others, State oil is usually heavier than Able oil. Able oil contains a large per cent. of decomposition products, State and water white smaller amounts, as indicated by the table. In the case of extremely heavy oils, like mineral seal, a large amount of acid is retained on account of the difficulty experienced in washing.

Amounts of acid varying from three to seven grains per gallon may also be found in distillate which has never been treated with acid. This arises from the oxidation of sulphur compounds which exist in the distillate from nearly all crude oils. For this reason the distillate become colored by long standing, especially if exposed to sunlight.—*C. I. Robinson.*

A METHOD OF SEPARATING THE TWO ISOMERIC TOLUIDINE-SULPHONIC ACIDS.

By E. A. Schneider.

While working with the toluidine-sulphonic acids for the purpose of making the hydrazine-sulphonic acids used in the above experiments, I made the observation that the potassium salt of *p*-toluidine-*m*-sulphonic acid, which is very easily soluble in water, is insoluble in cold caustic potash, while the potassium salt of *p*-toluidine-*o*-sulphonic acid is extremely easily soluble in the same liquid at ordinary temperature. The same is true of the corresponding sodium salts. If it is desired to separate a mixture of the two acids into its components, it is only necessary to heat it with concentrated caustic potash until it has all passed into solution. If this solution is allowed to cool slowly, the potassium salt of *p*-toluidine-*m*-sulphonic acid crystallizes out in stout needles, which can be easily separated from the mother-liquor by means of a platinum cone and a filter pump. It is advisable to wash the salt in the funnel with alcohol, and then quickly to press it between layers of filter paper.—*Amer. Chem. Jour.*

ALKALINE CHROMATES.

Chromic acid behaves with the alkaline bases like a bibasic acid having two distinct functions. As regards potassa, the first function of chromic acid, that which yields bichromate, is surpassed only by the first function of sulphuric acid, which yields potassium bisulphate. It is very near that of hydrochloric acid, and is certainly superior to the carbonic, acetic, and even phosphoric acids. Hence potassium bichromate undergoes no notable decomposition except with sulphuric acid, which, moreover, does not occasion any change of color in the liquid. Potassium bichromate, which retains the second function of the chromic acid and forms neutral chromate, ranks below hydrochloric acid, potassium bisulphate, acetic acid, and the first function of phosphoric and carbonic acids. But it appears to be an acid stronger than potassium bicarbonate and the third function of phosphoric acid. The action of powerful acids upon neutral potassium chromate tends to the total displacement of the bichromate in favor of the new acid.—*P. Sabatier.*

WHY SOME PEOPLE GROW FAT.

CARBOHYDRATE AND FATTY FOODS.*

By N. A. RANDOLPH, M.D., Philadelphia.

UNDER the general heading of fats is recognized a certain group of bodies composed of carbon, hydrogen, and oxygen, which are capable of saponification and of emulsification, and which are insoluble in water. The true or neutral fats belong to one of three groups—stearine, palmitine, and oleine, margarine being usually accounted a combination of the first and third. Chemically, each of these bodies is analogous in composition to any of the neutral salts. In the fats, however, the acid radical is represented by a fatty acid, and the base by glycerin. Thus, stearine may be regarded as the union of stearic acid with glycerin, and palmitine and oleine as respectively a palmitate and an oleate of glycerin. The fatty acid is, however, by far the preponderant portion of the molecule, the glycerin never exceeding from eight to ten per cent. of the substance. The fats named have been mentioned in the order of their solidity at ordinary temperatures, stearine being hard and oleine entirely fluid under usual conditions, while palmitine occupies an intermediate position in regard to density. As foods, these bodies are of extreme importance, though their full value has not been appreciated until a comparatively recent period, because, when taken to the exclusion of other foods, continued nutrition becomes impossible.

We eat fat in a nearly pure state in lard, in oils, and in butter. It exists in varying amount in every organic food. Thus we find in

Meats, five to ten per cent.
Eggs, twelve per cent.
Milk, three to four per cent.
Butter, eighty to ninety per cent.
Cheese, from eight to thirty per cent.
Almonds, and nuts in general, fifty-three to sixty-six per cent.
And in all vegetables, from traces to two and three per cent.

Fat is an integral constituent of the higher animals, being entirely absent only in the lowest. It is found not simply in the great reservoirs of the subcutaneous connective tissue, in the omentum, and around the kidneys, but also, finely divided and invisible to the naked eye, in every organ and fluid of the body. Its subdivision is so minute, and its distribution so wide, that, especially for muscular tissue, it has been well described as being "amalgamated" with the tissue. The chemical composition of fats of different animals is comparatively constant. The mean of eight analyses, including the fat of the ox, sheep, pig, dog, man, cat, horse, and butter, revealed an average constitution of $C_{76.5}H_{11.9}O_{11.6}$, while in the separate analyses these figures differ scarcely one per cent. from one another. Curiously enough, however, the difference in the chemical constitution of the fats of different animals gives to these animals their characteristic odors.

Just as in the body as a whole we find an inverse ratio between its fatty and watery constituents, so in the fatty tissues proper we find a similar relationship. This is strictly correlated with the histogenesis of adipose tissue, *i. e.*, the fat globules are produced in the connective-tissue corpuscle at the expense of the contained watery protoplasm. From figures gained by actual analyses, it may be stated that in the average healthy adult the fat equals eighteen per cent. of the entire body-weight, or forty-four per cent. of the weight of the dried body.

The extremes in the proportion of fat in the body coincident, apparently, with health have been most carefully studied in the domestic animals. Thus, in sheep of different degrees of fatness, the following percentage relations in their proximate composition have been found to obtain:

	Per cent. Water.	Per cent. Albumen.	Per cent. Fat.	Per cent. Ash.
Thin sheep.........	57·3	18·4	18·7	3·16
Moderately fat sheep.	50·2	14·0	23·5	3·17
Fat sheep...........	43·4	12·2	35·6	2·81
Very fat sheep........	35·2	10·9	45·8	2·90

In order to appreciate the importance of fats in the economy, we must turn to the phenomena occurring as a result of abstinence from food. In this condition, there is constant disintegration of albumen and fat, the destruction of the latter being twice as great as that of the former. To prevent further loss of fat, either albumen, fat, or carbohydrates must be given.

That by its metabolic activity the body can make fat out of other than fatty substances is fully established. A cow subsisting on hay alone accumulates and secretes many times as much fat as she takes in her food. A woman in lactation also secretes much more fat than is ingested. In the process of fattening pigs, it has been shown by direct analysis at the end of the experiment, that for every 100 parts of fat in the food consumed, 472 parts of fat are stored up in the body. Perhaps the most striking illustration of metabolic fat production is found in the experiments conducted by Hoffmann on a maggot's eggs. The fat percentage in a given weight of these eggs was determined, and a corresponding quantity were allowed to develop in defibrinated blood. When the maggots became mature, it was found that the fat in the eggs from which they were developed, plus the fat in their food, constituted a little less than one-tenth of the fat extracted from their bodies. Here the fat production could be attributed only to separation of albuminoids into other nitrogenous matters and fats.

Pathologically, we frequently see a retrograde metamorphosis of albumen, which constitutes fatty degeneration. Somewhat similar in nature is the post-mortem production of adipocere, in which the proteids of the body have been broken up, possibly by bacterial agency, with the production of the higher fatty acids. The bodies last named unite with earthy and ammoniacal bases to form an insoluble soap, which replaces and assumes the form of the destroyed tissues. As a result of poisoning, especially by phosphorus, there is also noted a similar production of fat resulting from the decomposition of albumen.

Admitting now that fat may be made in the body from albumens, it becomes interesting to note the amount of albumen requisite in the otherwise starving animal to prevent for a time any loss of fat. This quantity is large, and is in inverse ratio to the amount of fat already in the body. In very meager individuals it would be impossible to prevent loss of fat under these circumstances, as the requisite amount of albumen would be more than could be digested. By the addition, however, of a small quantity of fat to the albumen, a much smaller quantity of the latter is sufficient to prevent decrease either of the albuminous or of the fatty tissues. As we shall see in studying the history of the proteids of the economy, the most rapid destruction of these compounds takes place, not in the formed tissues, as was formerly supposed, but in the circulating fluids. Close chemical studies have shown that, when fats are present in company with the circulating albumens, they greatly retard the destruction of the latter. In other words, the functionally active cell in any part of the body is bathed in a fluid containing both proteid matter and fat. Only a portion of the force of that active cell is derived from the disintegration of the albuminoid, the remainder being gained from the destruction of the fat. It is especially under muscular activity that the destruction of the fats is most marked, and for this reason they form a most important element in the dietary of the laboring classes. This power of fats to prevent the destruction of the albumens of the body is illustrated by the fact that a moderately fat individual will resist starvation for a longer period than will one of equal muscularity, but greater specific gravity. Nevertheless, fat alone is a very insufficient food. It retards the destruction of the albumens, and therefore prolongs, though it cannot sustain, life. Thus, Magendie fed two dogs, one on butter, the other on lard, without other food. The first lived sixty-eight days, the other fifty-six. The post-mortem examination showed an accumulation of subcutaneous fat, but general atrophy of the organs. Rats also, which, in the absence of all food, starve in from three to nine days, will live upon fat for from twenty-six to twenty-nine days.

Under normal conditions, the fats ingested are absorbed with remarkable completeness and in surprising quantity. Thus, in a dog of nearly eighty pounds weight, to which was given in one day eleven ounces of fat in conjunction with other food, a little less than a drachm of fat could be obtained from the fæces. The maximum limit of fat absorption is not yet established, but it is doubtful whether the amount last mentioned could be absorbed during many successive days. On the contrary, it is highly probable that a degree of saturation of the circulating fluids would be obtained beyond which further absorption would not occur. Experiments instituted by the writer (aided by Dr. Roussel) upon twenty healthy individuals (both infants and adults), with a view of determining the question of the cutaneous absorption of fats, gave the following results:

At the beginning of the experiments, the fæces were, in each case, found to be practically free from fat. After continued inunction of cod liver oil, applied twice daily for a period of two weeks, there was found not only a gain in weight of the individuals (with whom the general dietary had been unchanged), but a notable quantity of fat present in the alvine dejections. This could only be attributed to a kind of saturation of the fluids of the body, which, as a result, prevented further absorption of fat from the intestinal surface, the fat found in the dejections corresponding, therefore, to unabsorbed fat taken in the food. This supposition is strengthened by the observations of Berthe, who showed that pure cod liver oil, given internally, could be taken for a longer time without appearing in the fæces than could an equal amount of butter or any of the other animal and vegetable fats.

When we remember that the absorption of ingested fats is, in all probability, a result of the purely vital activity of the protoplasm of the intestinal epithelium, it is not difficult to understand the rejection of a needless aliment by this absorbent surface. It is a manifestation of protoplasmic selective power analogous to that exhibited by two dissimilar plants drawing from the same soil each its distinct and special pabulum. Such intestinal selection is illustrated by the behavior of petrolatum (cosmoline, vaseline) in the digestive tract. This substance, while non-saponifiable and chemically distinct from the fats, presents many points of physical resemblance. Prompted by this resemblance, the query arose in my mind, a few months ago, as to the possible absorption of this soft hydrocarbon by the human digestive tract and its subsequent oxidation in the tissues; in other words, whether it could or could not be utilized as a food. On each of eight days I swallowed half an ounce of commercial vaseline, and caused my laboratory assistant to do the same. Digestion was not disturbed in either case, and no noticeable effects ensued. Later, to each of two healthy adults there was given, in the course of forty-eight hours, one ounce of vaseline. Their fæces, for three days from the beginning of this experiment, were collected, dried, and extracted with petroleum ether. From the extract the vaseline ingested was entirely recovered—evidence of its complete rejection by the intestinal surface. In further experiments upon other individuals, I have found that petrolatum, administered internally, is often sufficient to check rather severe diarrhœas of irritation, apparently acting simply as a mechanical lubricant, which exerts its soothing effect upon the entire irritated surface. It is a curious fact that petrolatum is also efficient in relieving constipation, its action being, of course, that of an unabsorbable diluent of the intestinal contents. The amount requisite to produce the desired result is in this case, however, too large to render the method one of any general usefulness.

In abnormal conditions, such as mechanically obstructed or otherwise impaired biliary or pancreatic secretion, or from diminished activity (from any cause) of the intestinal epithelium, fatty stools are noted. In heath, however, fat is found in but minimal amounts in the excreta, although other unabsorbed food elements—bits of muscle fiber, starch, etc.—are readily found. Curiously enough, the presence in the intestinal contents of bran, woody fiber, and the like, materials which impede the proper digestion and absorption of the proteid foods, has little or no effect upon the practically complete absorption of fats. Rubner has shown that the human intestine can absorb large quantities of fat—much larger, indeed, than in the case of the dog just cited; but the length of time during which such absorption could be continued was not determined. In comparison with ham fat, he found butter to be by far the more readily absorbed. Previous accurate observations, already cited, have shown that cod liver oil is absorbed with greater ease and to a greater degree than any of the other fats. The vegetable oils, on the other hand, are the least readily absorbed.

In every sound nutritive schema we find that the fats occupy a prominent position. It is very significant, in this connection, to note that in the first food of the mammal the fats and albumens are present in practically equal parts. It, of course, goes without saying that a fat which is not entirely fluid at the temperature of the viscera is with difficulty susceptible of emulsification and absorption, and may prove an irritant to weak digestive organs. Although the fats of high melting point contain olein, which is fluid at ordinary temperatures, there is also present sufficient stearine to render a higher temperature requisite for melting the mixture. Thus, the melting point for the fat of mutton is from 41 deg. to 52 deg. C.; for beef, 41 deg. to 50 deg. C.; for pork fat, 42 deg. to 48 deg. C.; whereas the fat of the horse, rabbit, and goose is fluid at from 24 deg. to 30 deg. C. These facts suggest the cause of the widespread preference for fats which, in popular phrase, "melt in the mouth."

When digestion and absorption are imperfect, fats may become irritants by undergoing a decomposition which exceeds physiological bounds, with the production of volatile and irritant fatty acids possessing characteristic rancid odors. Somewhat similar decompositions occur at the temperature requisite for frying. This we must regard as one factor in the frequent cases of indigestion of fried foods; and a further reason that the fats, especially when cooked with other foods, are frequently found to be unwholesome is that, in the process of cooking, they so surround and saturate the tissues of the substance with which they are combined that it is rendered nearly inaccessible to the action of the saliva and gastric juice, and at times digestion is in so far delayed that the fried substance does not become entirely freed from this more or less impervious coating of fat until subjected to the action of the pancreatic juice.

Under ordinary circumstances, the fatty acids of the neutral fats are not taken into the economy as such, but in combination with a small amount of glycerin. The fatty acids, however, alone are fully capable of replacing the neutral fats as a food. When administered to a dog in the form of soaps, in conjunction with meat from which all fat had been removed, Munk found that the animal gained in weight in precisely the same way that it would have done had the acid been given in its more usual combination. No nutritive value, strictly speaking, has as yet been determined for the glycerin found in fats, but it is believed that, in the form of glycero-phosphoric acid, it carries phosphoric acid to the tissues where the latter acid is needed. It is quite well established that the lecithins, which are important constituents of brain tissue, are direct derivatives of glycero-phosphoric acid.

A carbohydrate is a compound of carbon, hydrogen, and oxygen, in which the elements last named are in the proportion requisite for the formation of water. The carbohydrates of the economy and of its foods may be grouped in four classes.

The first includes the glucoses, which possess the formula $C_6H_{12}O_6$. The word glucose may be used as synonymous with grape sugar, dextrose, starch sugar, and liver sugar. Glucose is constantly found, in minute quantity, in blood, chyle, and muscle. An excess above the small maximum normal to these tissues is immediately rejected and excreted; thus, a solution of glucose injected into a vein at once makes its appearance in the urine, and the glycosuria of diabetes mellitus is attributed to a nervous disturbance of the hepatic function, which permits the entrance into the circulating fluids of a greater amount of this substance than is normal.

In the vegetable kingdom glucose is widespread, being found in the sweet juices of ripe fruits and in the honey of flowers. It is physiologically produced in germinating seeds by the action of the amylolytic ferment therein contained. It is crystallizable, combines feebly with bases, salts, acids, and alcohols, and has a reducing action on many metallic oxides. By fermentation with yeast it separates into alcohol and carbonic acid, and in the presence of decomposing albumen it splits into two molecules of lactic acid, which, in alkaline solutions under the same conditions, may be yet further decomposed into butyric and carbonic acids and hydrogen. To this group belong, also, galactose, produced by the action of diluted acid upon sugar of milk, and levulose, an isomeric body, which, however, rotates the ray of polarized light to the left. It is a by-product in the intestinal digestion of starches.

The second division of the carbohydrates contains those of the formula $C_{12}H_{22}O_{11}$, commonly called the saccharoses. They may be regarded as anhydrides of the double glucose molecule. Their physiological type is lactose, or milk sugar, and their type, from a dietetic point of view, is cane or beet sugar. Lactose is capable of change by direct fermentation into lactic acid, and indirectly by yeast into alcohol, as in the production of koumiss. Cane sugar is, in some degree at least, transformed into glucose before it is absorbed.

The third group includes the carbohydrates of the formula $C_6H_{10}O_5$—*i. e.*, starches, dextrine, cellulose, gums, and glycogen. One of the most striking differences between the green plants and all animals lies in the power possessed by the former of manufacturing starch from inorganic substances. The chlorophyl of the green plant, when stimulated by sunlight, can induce the union of six molecules of atmospheric carbon dinoxide with five molecules of water, with the resultant production of one molecule of starch and the liberation of oxygen. No such synthetic power is possessed by any animal, and for the manufacture of a carbohydrate in the animal there is requisite, therefore, either a pre-existing carbohydrate or the destruction of an albuminoid. Starch, in its raw state, is entirely insoluble in water. When boiled, the granulose, which constitutes the major portion of the starch grain, and which is contained within an enveloping membrane of cellulose, becomes swollen and ruptures the membrane, with the production of the common starch jelly or paste. Such mechanical hydration of the starch granule is very essential to its digestibility, as the cel-

* A lecture delivered before the Franklin Institute, December 14, 1885.

lulose envelope is but little affected by the saliva. The pancreatic juice, howe er, is fairly useful in dissolving even raw starch. Starch frequently causes indigestion when eaten in large quantities, from the following causes:

1. Glucose may be formed more quickly than it can be absorbed, and, by its presence, retard the further digestion of the starch.

2. Starch, when long retained, is liable to fermentation, with the evolution of butyric acid, thus causing persistent diarrhœas, especially in early childhood.

Much diversity of opinion exists as to the digestion of starches in infancy. I have settled this point to my own satisfaction by the microscopic examination of the fæces of twenty-four starch-fed infants, aged from forty-five days to eighteen months.

The results of this study will be found in the following table:

No.	Age.	Food.	Starch Present.	Remarks.
1	45 days.	Condensed milk and cracker dust.	None.	
2	2 months.	" " " "	Traces.	
3	2 + "	" " " "	"	
4	3 "	" " " "	"	Twice examined; no fat before inunction, about 10 per cent. after.
5	3 "	" " " "	"	
6	3 "	" " " "	About 1/4 starch.	
7	3 "	" " " "	Traces.	
8	4 "	Corn-starch and milk.	"	
9	4 "	Condensed milk and cracker dust.	None.	Many broken cellulose envelopes.
10	4 + "	" " " "	Traces.	Evidences of potato surreptitiously given.
11	5 "	" " " "	About 1/2 starch.	
12	5 + "	" " " "	None.	
13	5 + "	" " " "	"	Many bacteria.
14	6 + "	" " " "	"	10 per cent. fat; had had inunctions.
15	8 + "	Breast and cracker food.	Traces.	
16	10 + "	Condensed milk and cracker dust.	More than normal.	Many bacteria; evidences of potato surreptitiously given.
17	13 — "	" " " "	20 to 30 per cent.	Some glucose present, and indications of dextrin; saliva was found to be inefficient.
18	14 — "	" " " "	Traces.	
19	14 "	" " " "	"	
20	14 "	" " " "	10 per cent. starch.	Sick.
21	14 + "	" " " "	None.	Except a few large cells containing starch from potato.
22	17 — "	" " " "	"	
23	17 — "	" " " "	Over 3/4 starch.	Syphilitic; saliva was found to be inefficient.
24	18 "	" " " "	Traces.	Indications of dextrin.

It should be observed that the word "traces," applied to the presence of starch in the fæces, does not indicate inefficiency of starch digestion. Similar traces of starch are found in the fæces of nearly every healthy adult upon a mixed diet.

It may legitimately be deduced from this study that in *many* cases starch is well digested in early infancy, that the individual variations in this regard are too numerous to permit any sweeping statement, and that the physician may assure himself as to the peculiarities of the case in hand only by a direct examination of the dejecta.

If an infant cannot digest starch, it is self-evident that starch is worse than useless as an ingredient in its food. The converse of this does not obtain; the mere fact that a given infant can digest a certain quantity of a farinaceous material is in itself no proof that such material is a useful ingredient in the dietary of that infant. The ratios existing in human milk between carbohydrate, fat, and proteid cannot with safety be greatly altered in an artificial food for early infant life.

Dextrin is prepared by superheating dry starch, and is also found as an intermediate product in the action of dilute acids and of digestive juices upon starch. It is chemically isomeric with the starch, but presents certain physical differences from this body, being soluble in water, and also much more tenacious as a mucilage. Dextrin is probably absorbed to some degree unchanged from the digestive cavities, inasmuch as there is found in the blood of the portal vein during digestion a substance which gives characteristic reactions, and possesses its properties.

Cellulose is found inseparably associated with the formed tissues of the vegetable kingdom, being one of the chief constituents of the vegetable cell-wall. Its digestibility depends largely upon its age and upon the extent to which it has been cooked. When young and tender, as in celery, asparagus, and salads, about one-half of its substance is digested, the remainder being of service in giving the proper bulk and consistence to the intestinal contents. This it does, however, at the expense of the complete absorption of the proteid food stuffs.

The gums possess no permanent nutritive value. Many authors claim that they are entirely unaffected by the digestive processes, but later studies have shown that they are absorbed to the extent of from forty to fifty per cent.

Glycogen, besides being a normal constituent of the human economy, is found in many foods. It is always present in the normal liver in varying amounts, the maximum being obtained in the livers of cattle, where it forms from fourteen to seventeen per cent. of the entire liver substance. It is further found in muscle, in most embryonal tissues, and, according to Pavy, also in the spleen, pancreas, eggs, brain, and blood. It is present in considerable amount in the large livers of oysters and other mollusks.

The fourth division contains but one member, viz., inosite. This is a sweetish sugar, isomeric with glucose, but entirely incapable of other fermentation than the sarcolactic. It is variously known as muscle-sugar, bean-sugar, and phaseomannite. It exists normally in muscle, where it is decomposed by each muscular contraction, with the resultant production of sarcolactic acid. It has also been found in lung, liver, spleen, kidney, and brain of oxen. It exists normally in the human kidney and pathologically in the urine. It is found in all the leguminosæ, and also in grape juice.

We have seen that there are present in the tissues of the body both fats and carbohydrates. The origin of the various carbohydrates is, in greater part at least, directly or indirectly from similar carbohydrates taken as food.

Thus, for instance, the glycogen of the liver greatly diminishes in amount in the absence of carbohydrate food stuffs. This is not the case with the fats. Foods containing starch and sugar are well known to be fattening. The explanation of this would at first sight seem to be that fat is made out of these bodies by the metabolic activity of the tissues. This explanation, however, is not correct. The true cause of the increase of body fat upon a mixed diet containing an excess of carbohydrates lies simply in the fact that these bodies become oxidized in the place of the albumens, thereby sparing the latter to fulfill their nutritive functions, and finally to produce fat. The ingested fats aid in the production of fat in the economy, both in this indirect manner and also directly replacing fats already oxidized and disintegrated.

It will be seen from this brief statement that in a mixed diet containing inorganic foods, proteids, fats, and carbohydrates, the members of the last two groups are capable of replacing one another to a large extent, for their functions are practically the same, *i. e.*, each sacrifices itself in the oxidation flame of life for the sake of the more valuable proteid tissues and fluids. This is more marked in the case of the carbohydrates, which are able almost entirely to replace the fats in a dietary. Under these circumstances, however, there is found to be a considerable tax upon the metabolic activity of the tissues in manufacturing the fats. In like manner, animals fed exclusively on meat will manufacture from their own tissues the needed carbohydrates in much greater quantity than that in which they exist in the food taken. But here again comes a strain on tissue metabolism, and practically it is found that, other things being equal, it is best to have both the carbohydrates and fats present in the food.

Thus far we have considered similarity in the two groups of organic non-nitrogenous foods. There are, however, certain differences. Thus, a given weight of fat represents one and three-fourths times the nutritive value of the same weight of sugar or starch. Although both of these bodies are heat producers, the fats again have the advantage, and it is for this reason that they assume such high nutritive importance in cold countries, and are consumed by us to a much greater extent in winter than in summer.

The direct bearing which these facts have upon the subject of corpulence is evident. The man who is fat does not of necessity partake too freely of starch and sugar or of oils. He is simply a man who eats too much. His powers of digestion, absorption, and especially of assimilation, are usually far superior to those of his thin neighbor, who may, and often does, eat far more than his obese friend. The plump patient, therefore, must not console himself with his relative temperance in food. He stands perpetually self-convicted as a man who consumes more nutriment than is needed to repair his daily wear and tear. So active are the nutritive processes in his body that he can say with poor Byron, "Everything I eat turns to tallow, and sticks to my ribs." He can, of course, reduce his fat by abstinence from carbohydrates and fats, but in so doing he not only violates his nature by turning carnivore, and seriously taxes his emunctories in eliminating an excess of nitrogenous waste, but he needlessly alienates too much tissue force by the tax and strain of excessive metabolic activity. To permanently and harmlessly reduce his bulk, it is necessary simply to very gradually reduce the daily total of his aggregate mixed diet. The popular belief that the ingestion of much fluid is fattening probably arises from observations of the use of fluids other than water.

Given the same degree of obedience on the part of a fat and of a thin patient, it is generally much easier to reduce the former than to fatten the latter. In the first case, it is purely a question of abstemiousness; in the second, the simple administration of food in excess of the bodily needs, if unaided by a corresponding stimulation of the assimilating powers, is not infrequently worse than useless. Such a nutritive stimulus may be obtained by the conjoint use of enforced rest, passive exercise by massage and electricity, and a dietary gradually increasing in bulk and variety, the chief factor in which is milk.

For the details of this latter process, I would refer the reader to that gem of medical monographs, Mitchell's *Fat and Blood*.—*Jour. Fr. Inst.*

CORAL FISHING.

Though Naples, or at least Torre del Greco, is one of the great centers of the coral trade, the material found in the gulf is both small in quantity and poor in quality. There are submarine rocks, well known to the fishermen, though they are laid down on no chart, where a piece or two may almost always be found; but they are so few, and their yield is so precarious and meager, that by a private agreement among the boat-owners each of them is only fished once in every three years. There can be little doubt that other and more fruitful fishing grounds are still undiscovered. In the opinion of many who ought to be well informed, wherever a rock rises above the sediment which forms the ground of a great part of the bay at a depth of about three hundred feet or more from the surface, the chances are that coral will be found upon it. The discovery of such banks has hitherto been almost entirely the work of chance. When a deep-sea fisher found a branch among the refuse of his nets, he gave information to the proper authorities, and received a reward proportionate to the value of his find.

It was thus that the great bank of Sciacca, on the coast of Sicily, was discovered, of which we shall have to speak further on. But, though new fishing grounds may be found in the Bay of Naples itself, it is not likely that they will have any great importance. The value of coral depends on its color and its size. The white or rose tinted variety stands highest in popular esteem, perhaps chiefly because it is the rarest. It is mostly found in the Straits of Messina, and on some parts of the African and Sardinian coasts. The bright red coral, in which the polyps are still living when it is fished up, stands next in value. Dead coral has a duller tint, and is consequently sold at a lower price. Two entirely different substances bear the name of black coral. One of them is not, properly speaking, coral at all, and it is commercially worthless, as it breaks into flakes, instead of yielding to the knife, though it is often sold as a costly curiosity to foreigners. The other is the common red coral which has undergone a sea change, probably through the decomposition of the living beings that once built and inhabited it. It is not much admired in Europe, but in India it commands high prices, so that large quantities of it are exported every year. These are the four important distinctions of color, though they of course include intermediate tints which rank according to their clearness and brilliancy.

The coral fishery of Naples has now, for the most part, fallen into the hands of a few wealthy firms. Formerly fishermen would club together and try their fortune on co-operative principles, but this system has almost entirely died out. A few single *padroni* still remain, but their exertions are entirely confined to the gulf. They are usually men of experience, who can decide how the net is to be laid and drawn, and who hold the guiding rope in their own hands. The boat and the nets are theirs, and they pay their subordinates a fixed sum to serve under them for one or two days. The whole yield, under these circumstances, of course belongs to the padrone. The larger firms could make an end of these boatmen easily enough, but it is not worth their while to do so. The yield of the gulf is comparatively small, and houses that possess from ten to thirty large boats of their own find it more advantageous to purchase the rough material from the local fishermen than to crush them by a cruel and irresistible competition, as they train the men who are afterward employed in expeditions to a distance.

The instrument with which the coral is taken consists of two strong beams of hard wood, which are fastened together in the form of a cross by metal claspings, to which a weight is added. Strong hempen nets are fastened to the arms. When a bank is reached, this primitive instrument is lowered, and moved up and down against the submarine rocks by means of a capstan turned by the whole of the boat's crew, except the padrone, who directs the movement of the apparatus by means of a second rope, which is attached to the chief one some feet above the point where the latter is secured to the center of the cross. The coral branches are caught in the meshes of the nets, and remain hanging in them. Those that are broken off by the woodwork are usually lost. In some places, especially on the coast of Sardinia, the end of the arms is surmounted by a circle of curved iron teeth, like those of a garden rake, but larger and stronger, below which open nets are suspended. In this case the beams are nearly double the length of those generally used by the largest boats, as they often measure six or seven meters—that is, nearly eight yards from end to end.

It is only by this means that coral can be obtained from the lower surfaces of shelving rocks; but the teeth are apt to fracture the stems in such a way as to render them almost worthless, and so this form of the instrument is rarely used where the other can be employed. The banks, or rather rocks, that are most frequently visited lie at a depth of from 250 to 450 feet below the surface of the water; it is very rarely that an attempt is made to reach those which are lower than 600 feet. Indeed, it lies in the very nature of the case that, even if they exist, they should remain unknown, and that, if they were known, they would hardly repay the cost of fishing while it is conducted on the present system. They are scattered all along the coasts of the Mediterranean, sometimes close to the shore, and sometimes at twenty-four, or, even thirty, hours' hard rowing from it. At many stations there is a small local fishery; but the bulk of the trade, at least in Italy, is in the hands of large firms which, for the most part, have their centers in Genoa, Leghorn, or the Bay of Naples. These firms both supply and equip the boats, which, according to their size, are manned by five or ten fishermen.

In addition to these a padrone is allotted to each, who exercises large disciplinary powers. He is a man of knowledge and experience, and usually receives a percentage on the value of the season's take, as well as his regular pay. The selection of the crew of his boat is often left entirely to him; he is always consulted with respect to it, and enjoys a right of veto. The men are hired for the season, by agreement, for from sixty to seventy francs a month, a large part of which is usually paid beforehand, and their food, which is of the coarsest kind. As a rule, the season lasts from April to the end of September, but it depends greatly on the weather, as fishing is impossible in mist or when the sea is high. The labor is exceedingly hard. At

dawn the padrone calls his men, and, after a short prayer, the net is lowered; from then till sunset the work continues almost without interruption. The exertion required to let down and wind up the net under a blazing summer sun is extreme, and it has to be done on ship biscuit of the coarsest kind and water that, on the more distant stations, has often become foul by long keeping.

In the evening a sort of soup is made. Garlic and peperoni, the pungent fruit of a southern plant, are boiled in water; olive oil is added, and this is poured over biscuits which have been broken and placed in the dish. For months this diet is hardly varied, and yet the men retain their good spirits. After the evening meal has been taken, they indulge in guitar playing and singing, and on the more frequented banks the boats answer and vie with each other. In 1878 the discovery of the Sciacca bank, which lies at a considerable distance off the southern coast of Sicily, roughly speaking between Girgenti and the island of Pantellaria, caused a crisis in the coral trade. At one time nearly a thousand boats might be found fishing there, and seeming to form a city in the midst of the sea. Each of these is said to have taken between one and two hundredweight of coral a day. It is certain that within three years 88,000 German centners were taken from this bank alone. A great part of this coral was dead, and much of it was of the black color that only finds purchasers in the East. The large firms did everything in their power to prevent the market being overflooded. Many of them still retain hundreds, and some thousands, of cases which have never been placed in the hands of the artificers. Still the price fell, and it is only at a considerable sacrifice that the greater houses still keep their boats at sea and the workshops open; but they know that, if they let them fall, the fate of their old competitors in Marseilles awaits them, for both the fishing for coral and its treatment by the artificers depend upon traditions which, when they have once been lost, it is difficult to revive.

One of the matters of general interest which the bank of Sciacca placed clearly before those who were interested in it from other than a mercantile point of view, was the fact that not only were dead and live coral there found side by side, but that in many cases the latter was growing on the former. Signor Lo Bianco spent several days on one of the boats for the purpose of inquiring into this and other scientific matters. Few men possess a keener eye for such sides of nature, or have enjoyed so good an opportunity of training and regulating it as his connection with the zoological station at Naples has afforded him. In his opinion the original bank was submerged by volcanic action, and the mud killed the mature polyps. The germs and larval forms, which still existed in the water, settled upon such branches of dead coral as still rose above the sediment, and so began life anew. If he is right, the Sciacca is a kind of submarine Herculaneum.

There is not likely to be any immediate improvement in the coral trade. As soon as prices rise, the large firms will be tempted to sell a part at least of the stock they have hitherto reserved in the hope of better times. If the depression lasts, they may be compelled to do so, which would lead to a further fall. This can have but a small interest for the general public, but the sight of the boats whose crews sail or row for long distances without the aid of a compass, guided only by the stars or the glimpse of some distant headland, and in their fishing employ instruments which are said to have been hardly modified since the days of the first Roman emperors, may suggest a summer afternoon reverie.—*Saturday Review.*

FRENCH POINTERS.

THE dog show that is annually held at Paris meets with a success that is further and further justified by the beauty of the types exhibited to the public and connoisseurs. The dogs this year were divided into two series—French races and foreign ones.

Among French dogs, the most manifest improvement was seen in the pointers, especially the variety called the griffon—an animal with long stiff hair. Marco, a griffon belonging to Mr. E. Boulet, took the prize of honor as being the most beautiful animal of the kind exhibited. This dog is shown in the accompanying engraving, taken from *La Nature.*

The exhibition of foreign stag hounds, beagles, harriers, mastiffs, and pointers is said to have been particularly fine this year.

FRENCH POINTER MARCO.

COMETS AND METEORS.

To the Editor of the Tribune:

SIR: Professor Newton, of Yale College, has discussed the origin of meteorites in an address of considerable interest, before the American Association for the Advancement of Science, in session at Buffalo. It appears to me, however, that he has neither recognized the full nature of the difficulties which the problem presents, nor the very striking character of the evidence on which our opinion as to its solution must depend. May I be permitted to indicate in brief here the evidence—to my mind overwhelming—in favor of my theory of the origin of comets and meteors?

I first note that no other theory is attacked, for no other theory exists. Professor Newton points out that comets are the only celestial bodies which have ever been observed to break up, and as meteorites are fragmental products, here is their true origin! And Schiaparelli has gone a little further back. Comets occasionally travel on paths passing very near one or other of the giant planets; probably, then, such comets owe their introduction into our solar system to the capturing power of such giant planets; they had been traveling as flights of meteoric bodies through the interstellar spaces, were drawn toward the sun, chanced to approach a giant planet, and were forced thereafter to pursue a closed path around the sun. Supposing all this possible, supposing it all proved, there would still be no theory of the origin of meteors and comets. Meteors come from comets; and comets are formed out of flights of meteors traveling amid interstellar space; but—how came the meteor flights to be traveling there? As a mere matter of fact it may be proved mathematically that no giant planet could capture a meteor flight (to say nothing of those meteor systems whose paths pass near no giant planet); while it may be proved physically that no meteorites could be broken off such bodies as we know comets to be (the real separation is merely the division of a meteor cloud into two clouds, not a stripping off of individual meteorites from a meteoritic mass). But even if these difficulties had no existence, the suggestion that meteors come from comets, and that comets are formed from flights of meteors, cannot help us in the least toward a solution of the problem: Whence came comets and meteorites?

The facts for our guidance are numerous and decisive—so numerous and so striking that it is not easy to decide in what order they should be taken.

First.—We have the evidence of Daubree that meteorites are absolutely identical in structure with terrestrial volcanic products such as are only found at great depths beneath the surface. They were formed, it is certain, under such conditions of high temperature and tremendous pressure as only exist deep within the mass of a planet or of a sun.

Secondly.—Sorby, of Sheffield, has demonstrated by microscopical examination that meteorites were formed under immense pressure and at high temperatures such as only exist in the interiors of suns or of bodies such as our earth and her fellow planets when these were in the sunlike stage of their career.

Thirdly.—Graham showed that certain iron meteorites contain occluded within their substance such quantities of hydrogen as indicate tremendous pressure in a region occupied by intensely hot hydrogen, convincing him that such meteorites have brought to us across the interstellar depths the hydrogen of some fixed star or sun.

Fourthly.—Comets, which are known to be meteor clouds, travel on such paths as to form comet families severally associated with the giant planets. It has been demonstrated that the planets could not have captured meteor flights after the manner imagined by Schiaparelli. There remains no other reasonable explanation but that the meteor flights are products of some sort of planetary ejection or rejection, which must have been from the interior, and effected while a planet was in the sunlike stage, to be reconciled with the discoveries of Daubree, Sorby, and Graham.

Fifthly.—There is a class of meteoric bodies, to be counted by millions of millions, which the earth captures in such profusion that Stanislas Meunier and Tschermak consider a terrestrial origin practically demonstrated. Ball has discussed their reasoning mathematically, and regards it as sound. Here again we require a volcanic ejection, taking place under such conditions as could only have existed when the earth was in the sunlike stage.

Sixthly.—The only body in a sunlike state to which we can address questions on this subject—the sun—answers emphatically in the affirmative, that he can and does eject bodies from his interior with the enormous velocities required for final rejection. The giant planets would have had much less power of ejection, but then they would have needed much less, their power of recall (*i. e.*, their attractive energy) being much smaller. Our earth and her fellow terrestrial planets would have had much less power still, but would (in like manner) have needed much less.

All the evidence tends not merely to show, but to prove, that all orders of meteors, and therefore all orders of comets, came from the interior of bodies like the suns and the planets when in the sunlike stages of their respective careers. All the evidence tends further to prove that sunlike bodies have the power of ejection which this proved theory of meteoric origin requires. It would be certain from one class of facts that bodies having the characteristics of meteors and comets must exist, even if no such bodies had been observed. It would be equally certain from another class of facts that since meteors and comets exist with such and such characteristics, such processes must be at work as could alone produce them. When we recognize at the same time the processes at work which we might have inferred from their observed products, and the products existing which we might have observed from the observed processes, we have our opinion confirmed with a double certainty such as we cannot often expect in scientific inquiry. Our theory is not only caught, and in the stable, but is locked there and double locked.

We may be assured, then, that if difficulties appear, they must admit being readily disposed of. Their discussion will probably lead to new truth.

Now there is but one objection of any weight. It presents itself indeed in a double form, as advanced by Professor Newton. For he reasons that while there is a difficulty in supposing that terrestrial or lunar volcanoes could have ejected meteoric bodies with the necessary velocity for absolute rejection, solar volcanoes could not eject solid bodies. This is but one objection. For it is to the sunlike stage of any planet's life that we are to look for the time when ejection of the kind required was possible; and our sun is the only case of a sunlike body we can inquire into. If he cannot eject solid bodies, neither could any planet when it was a sun. But cannot and does not the sun eject solid bodies? Those who imagine the eruption prominences to be what they seem to be—jets of glowing gas—may be disposed to answer in the negative. But in reality nothing can be much less likely than that the jet-shaped streaks of hydrogen were themselves ejected. Manifestly they indicate the tracks of denser bodies, not themselves visible because the spectroscope will not show bodies near the sun which shine with all the spectral colors (as such bodies would), only those which shine with a few special tints (as the glowing hydrogen along the track of such bodies would shine).

Nor need we wonder that the bodies ejected from the sun's interior are solid even from the time of their exit, when we remember how the expansion of the compressed vapors driven forcibly upward from a solar volcano (far below the visible surface) would result in very rapid cooling, by which a portion of the vapor would necessarily condense into the solid form. In fact, this is the very process which Sorby recognized as indicated by the microscopic structure of meteorites.

It may doubtless be the case that of ejected meteoric bodies far the greater number return to the sunlike orb ejecting them. But if only one flight, consisting perhaps of thousands of small bodies, escapes from our sun in a year, of how many millions of such flights has he been the parent? His hundreds of millions of fellow suns have done and are doing like work; the thousands of millions of planets have done similar work in the past. Each flight would be a comet, each component body a meteor; and all that is known of comets and meteors would be explained by this account of their origin.

RICHARD A. PROCTOR.

St. Joseph, Mo., Sept. 6, 1886.

[NATURE.]

EARTHQUAKE RECORDERS FOR USE IN OBSERVATORIES.

Two years ago the writer described in *Nature* (vol. xxx., pp. 149 and 174) some of the instruments which he had designed and used in Japan for the registration and analysis of earthquake movements. In response to applications from the directors of several observatories, who wished to add seismometric apparatus to their other equipment, arrangements were some time ago made with the Cambridge Scientific Instrument Company for the manufacture of instruments by aid of which the observation of earthquakes might become part of the ordinary work of any meteorological or astronomical station where such movements occasionally occur. In the design of these seismographs, the object has been kept in view of making them easily capable of use by observers who have not made seismometry a special study. They are entirely self-recording, and require little attention during the long intervals which must, in most situations, be expected to elapse between one period of activity and the next.

One group of instruments is arranged to give a complete record of every particular of the movement by resolving it into three rectangular components—one vertical and two horizontal—and registering these by three distinct pointers on a sheet of smoked glass, which is made to revolve uniformly by clockwork. A single earthquake always consists of many successive displacements of the ground; hence the record traced by each pointer on the moving plate is a line comprising many undulations, generally very irregular in character. The amplitude, period, and form of each of these are easily

measured, and by compounding the three we obtain full information regarding the direction, extent, velocity, and rate of acceleration of the movement at any epoch in the disturbance.

This group of instruments is shown in Fig. 1. In the center is the plate of smoked glass, which gets its motion through a friction roller from a clock furnished with a centrifugal governor, acting by fluid-friction, and balanced so that its speed is not sensibly affected by the shaking of the ground. The clock is started into motion by means of a Palmieri seismoscope, which appears in the figure behind the plate, on the right. This is a small common pendulum whose bob carries at the bottom a piece of stiff platinum wire that projects into a recess in a cup of mercury below—the recess being formed by an iron pin standing lower than the surface of the surrounding mercury. On the slightest shaking of the ground, contact with the edge of the mercury takes place, and this closes a circuit which releases an electromagnetic detent and starts the clock. This occurs during the preliminary tremors which are usually found in advance of the main movements of an earthquake. The same circuit starts another clock (of the escapement type), which fulfills two functions. It marks time on the revolving plate during a part of the first revolution, and then continues to go as an ordinary clock, so that, by inspecting its dial afterward, the interval which has elapsed from the occurrence of the earthquake is known, and the date of the shock in hours and minutes is thus determined with as much precision as the phenomenon admits of. This part of the apparatus is omitted from the figure. The two horizontal components of motion are recorded by a pair of horizontal pendulums, set at right angles to each other, but with their indices inclined so that they write side by side on one radius of the plate. The pendulums are supported on a single stand, but with independent adjustments for position and stability. Each has two pivots, consisting of hard steel points, which turn in sapphire centers. At the pivots and at the tracing points every effort has been made to avoid friction. The indices are of aluminum, and a part of their weight is taken by springs (not shown in the figure), so that their pressure on the plate may be no greater than is necessary to produce a trace on the sooty film. The vertical component of motion is recorded by the instrument which appears behind the clock. A massive bar, free to move vertically about a horizontal axis, is held up by a pair of long spiral springs. Its equilibrium is made nearly neutral by applying the pull of the springs at a suitable distance below the horizontal plane through the axis of support, in the manner described in the article to which reference has already been made. A bell-crank lever with a jointed index gives a multiplied trace of the apparent vertical oscillations of the bar, which correspond to vertical displacements of the ground. In this instrument, as in the others, sapphire centers are used to minimize friction.

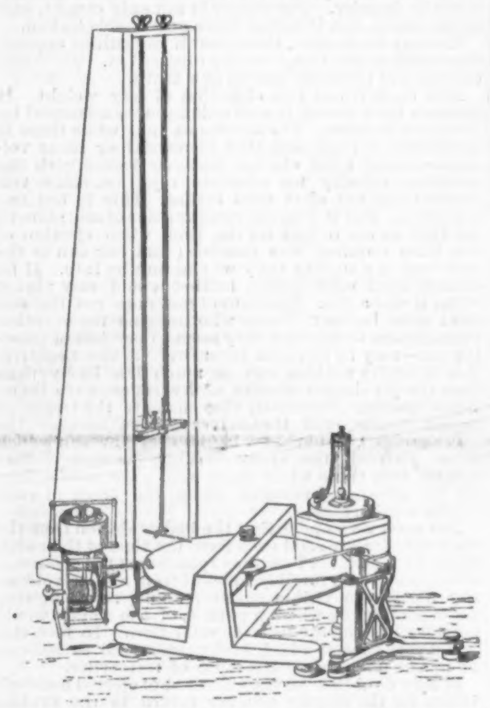


Fig. 1.—COMPLETE THREE-COMPONENT SEISMOGRAPH, FOR MOTIONS IN ALL DIRECTIONS.

Records inscribed on the plate are preserved by varnishing the plate, and using it as a "negative" to print photographs. The motion, as recorded, is magnified to an extent which experience of Japanese earthquakes has shown to be desirable in dealing with disturbances ranging from those which are just recognizable as earthquakes up to those which are to some extent destructive. For great earthquakes, separate apparatus of the same type is designed, in which the multiplying indices are dispensed with, and the scale and style of the other parts are considerably modified.

Another and distinct instrument, also manufactured by the Cambridge Company, is the duplex pendulum seismograph, shown in Fig. 2. A massive bob is hung by three parallel wires from the top of a three-cornered box, and is reduced to nearly neutral equilibrium by being coupled by a ball-and-tube joint to the bob of an inverted pendulum below it. The two form a system which can be made as nearly astatic as is desirable, and so furnish a suitable steady point for the horizontal part of earthquake movement in any azimuth. The motion is magnified and recorded by a vertical lever geared to the upper bob by a ball-and-tube joint, supported on gimbals from a bracket fixed to the box, and furnished with a jointed index which writes on a fixed plate of smoked glass. Records of the kind which the duplex pendulum gives are of course incomplete in two important particulars: they show nothing of the vertical motion (which, however, is usually a comparatively small part of the whole), and they show nothing of the relation of *time* to displacement throughout the disturbance. But they exhibit very clearly the change of direction which the movements undergo, and the actual direction taken by any pronounced element of the shock. The writer has recently learnt from his former assistant, Mr. Sekiya, now Professor of Seismology in the University of Tokio, that as many as fifteen of the duplex pendulum seismographs are in use by official and private observers in Japan.

The instruments shown in the figures are now on view at the Edinburgh International Exhibition (Court 21, No. 917). Similar sets are being made for the Lick Observatory, California, the Ben Nevis Observatory, and other places. It is scarcely necessary to add that they show the high finish and perfection of workmanship characteristic of the Cambridge Company's manufactures. To Mr. Horace Darwin the writer is especially indebted for a number of suggestions, the adoption of which has contributed much to scientific accuracy in details and simplicity in structural arrangements.

J. A. Ewing.

BAREFOOT HORSES.

Mr. P. B. Thomas, of North Attleboro, Mass., writing to the *N. E. Farmer*, says: In the spring of 1884 I bought a pair of Canadian farm horses. During the first twelve months that I worked them, I kept them shod, as is customary with most farmers; but finding at the end of the year that it had cost me in time and money about forty dollars, I was led to consider the expediency of "hoofing it." I had read that a few men had used horses without shoes, and were pleased with the result; I also knew of a horse passing my farm on a 150 mile journey shoeless, and not at all inconvenienced thereby. That superstition attached a favorable omen to the finding of a cast-off horse-shoe, I suppose must come somehow from the fact that a benefit resulted from an unshod foot. These facts were duly considered, and gave me faith to run the risk of working the animals without shoes. It is now—August 1, 1886—eighteen months since my horses were shod; they are working hard upon the farm and road without a flinch or difficulty of any kind. They are also driven in light carriages when convenience requires, being fine drivers as well as workers. They were kept in stable only five days in winter on account of ice. It has been stated that unshod horses can go on glare ice, but this is an error; they can go on rough ice quite well, however; they can do it much better than smooth shod horses, so I judge the one who made the statement made the mistake by calling rough ice, glare ice. My horses were tender footed for about three weeks after removing the shoes; they were used rather carefully during those three weeks, but never taken away from their work. Sometimes, when tender, I put them to work on plowed ground or greensward. The hoofs cracked a little around the edges, but nothing to do harm; they also showed tenderness after a freeze and thaw in early winter, frozen ground seeming to be better for them than mud. Constant usage does not wear the hoof, as some might suppose. There is a peculiarity about the foot of a horse worthy of mention. There is an adhesiveness to it, so that when he gives his foot the grinding motion, as in walking, the hoof is not ground off, as it would be did it not carry away a part of the earth it treads upon.

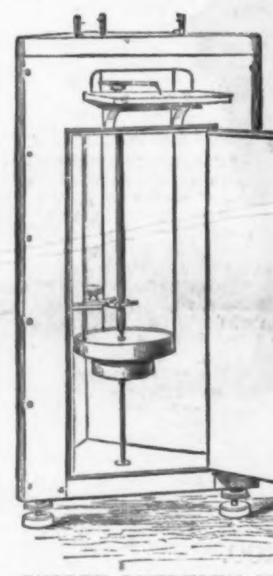


Fig. 2.—DUPLEX PENDULUM SEISMOGRAPH, FOR HORIZONTAL MOTION.

The advantages arising from using horses without shoes are so numerous that I must necessarily be debarred from mentioning them all. That the barefoot horse is always ready to go to work except on glare ice any one will readily perceive; that he is less fatigued on a long journey is also perceivable. That the iron shoe is the fundamental cause of a large percentage of the diseases of the horse's foot and leg, I believe is fast being demonstrated. The contracted hoof or "pinched foot," the ring-bone, the spavin, the wind-gall, the corn, the distorted tendon, etc., are among the most common ailments that arise largely from proper, as well as improper, shoeing. That the horse will last longer without shoes than with must yet be a conceded fact. It will yet be discovered and admitted by the masses that he can trot over hard roads, work in rough fields, and get around among stumps and stones more conveniently unshod than shod, and, consequently, may be held to labor for a longer term of years. Of the hundreds of men who have stopped my team upon the road and asked why we were using it unshod, not one has asked our opinion of its feasibility. Hence I very naturally conclude that people in general do not care to know, yet I cannot think that the intelligent readers of the *Farmer* are so bigoted or obtuse that they would not regard favorably the conclusions of one who has made an experiment. My conclusions, then, are briefly these: The iron shoe, at first, was seemingly a great convenience to the horse, but its continued use is calculated to do mischief, yet the defect is so long in showing itself that a majority of people have never attributed the cause of the same to the shoe. Horses are lame sometimes that never wear shoes, but I am satisfied, as above stated, that the difficulties would be much less were the horses left unshod. Number the horses of the country and average the cost of shoeing, and see if millions would not be saved to people were this plan adopted. This can be done without any conceivable drawback to ourselves. This is one of the great improvements this great country might adopt and be satisfied with.

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